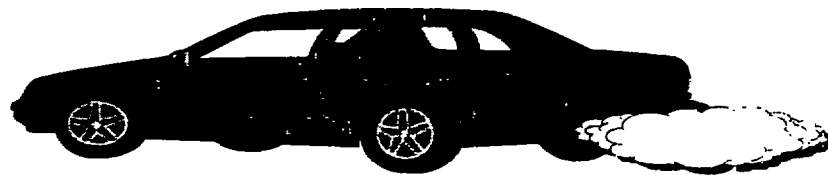


Evaluation. Report for ITS for Voluntary Emission Reduction: An ITS Operational Test for Real-Time Vehicle Emissions Detection

Prepared by:
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May 1997



NCECS
NATIONAL CENTER FOR VEHICLE EMISSIONS CONTROL AND SAFETY

The National Center for Vehicle Emissions Control and Safety (NCVECS), at Colorado State University, was established in 1976 by the U.S. Environmental Protection Agency (EPA). NCVECS was originally established to assist states across the nation in developing their vehicle emissions control programs. The Center's research and training efforts have grown beyond the original EPA mandate.

The research and testing activities at the Center are diverse. They include conducting the EPA's National Tampering Survey since 1984, laboratory research on alternative fuels and conversion kits, after-market devices, and other emissions-related research.

Training activities are also expanding to include a more diverse audience as well as additional topic areas. The following is a partial list of the topics covered in NCVECS training workshops: tampering detection and emissions, alternative fuels, quality assurance and quality control in Inspection/Maintenance (I/M) programs, and automotive testing equipment.

The annual Mobile Sources/Clean Air Conference hosted by NCVECS has become a premier gathering of individuals involved in Inspection/Maintenance, industry, government, and education. The conference attracts individuals from around the United States in addition to the international community.

NCVECS personnel maintain ties with various academic units on campus by serving on Graduate Committees for various departments, employing student hourly personnel, serving as co-advisor for the Mechanical Engineering Challenge vehicles, and by teaching two graduate level courses in the Industrial Sciences Department.

The Center has expanded its research and training efforts to include international markets. Training has occurred in Canada and staff members recently met with officials in Mexico City and Guadalajara regarding technician training and further research projects in various locations throughout Mexico.

EVALUATION REPORT

for

ITS FOR VOLUNTARY EMISSIONS REDUCTION:

**An ITS Operational Test for Real-Time
Vehicle Emissions Detection**

FINAL REPORT PREPARED BY:

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May 1997

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LIST OF ACRONYMS

CAAA	Clean Air Act Amendments of 1990
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CSU	Colorado State University
DU	University of Denver
FHWA	Federal Highway Administration
HC	Hydrocarbons
I/M	Inspection/Maintenance
IR	Infrared
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITS	Intelligent Transport Systems
IVHS	Intelligent Vehicle Highway Systems
LED	Light Emitting Diode
LPR	License Plate Reader
NCVECS	National Center for Vehicle Emissions Control and Safety
NDIR	Non-Dispersive Infrared
OTC	Owatonna Tool Company
RSD	Remote Sensing Device
RSIS	Remote Sensing Information System
RST	Remote Sensing Technologies, Inc.
SPSS	Statistical Package for the Social Scientists
USDOT	US Department of Transportation
VMS	Variable Message Sign/Smart Sign
VMT	Vehicle Miles Traveled

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EXECUTIVE SUMMARY

The Intelligent Transport System's (ITS) Operation Test Project was designed to assess the potential of ITS to support cleaner air by providing real-time vehicle tailpipe emissions information (carbon monoxide levels) to the driving public. It made an appeal to the driving public to accept responsibility for maintaining their vehicles, to increase gas mileage and minimize harmful tailpipe emissions.

The ITS Operational Test Project combined a variable message sign/SMART SIGN (VMS) with a remote sensing device (RSD). The merging of these technologies into a remote sensing information system (RSIS) made possible, for the first time, provision to the public of real-time tailpipe emissions information from the vehicle they are driving. The purpose of this project was to test the accuracy of the combined system and to evaluate the motorists' perceptions and responses to such a system. This was a unique project because it combined new technologies, provided the potential for dramatically increasing awareness, made an appeal to the minority of gross polluting vehicle motorists to accept responsibility for their dirty cars, and alerted owners of normally low emitting vehicles if an emission system failure had occurred.

A sample of motorists driving by the RSIS at 125 and Speer Blvd. were interviewed by telephone for the ITS Evaluation Project. The sample analysis was weighted to reflect the actual population passing the sign. The findings indicated that the respondents considered growth followed by air pollution to be the major environmental problems in Denver. The majority of the respondents believed that cars (especially when coupled with growth) were the number one contributor to the air pollution problem. Approximately one-third of these respondents stated that Denver's air quality was improving.

Most of the respondents thought central emissions testing, increased awareness of pollution and better cars were the most frequent reasons for the improvement in Denver's air quality. They thought that the technology of the SMART sign could enhance the existing emissions programs and that the SMART sign was a good way to periodically check their cars' performance. If the car's performance reading was not good, they would take their car in for repairs. Over one-half of the motorists interviewed thought it was a valuable tool for motivating people to repair broken cars. Almost two percent (1.6%) of motorists had actually done something in response to the sign (more men than women) and 8% plan to do something in response to the sign. Most respondents had favorable impressions of the sign. They seem to understand the relationship between well maintained cars, good emissions and fuel economy. Almost all agreed that "a well

maintained car can reduce air pollution” and that “a well maintained vehicle actually saves money”.

A smaller sub-sample of the population was interviewed using in-depth case study techniques to better understand the reasoning behind the responses to the questionnaire. The case study participants expressed an understanding of the link between well-maintained vehicles, air pollution and fuel economy. They were very favorable toward the sign and thought people would use it to regularly check the performance of their cars. Most of the case study participants thought the sign would encourage action to reduce air pollution in Denver.

The case study participants were also asked how much they were willing to pay to repair their car so that it would fall into the good category. Three-fourths of the case study sample said they would pay \$100 dollars or more. The case study sample was also asked for possible solutions to the air pollution problem. The need for mass transit was the overwhelming response, however, the use of the RSIS in combination with the Central Emissions Testing, if improved, was seen as the best way to control air pollution from automobiles.

The data indicates that the ITS RSIS has the potential to be an effective tool for encouraging people to voluntarily fix their cars in order to improve air quality and to increase fuel efficiency. The auxiliary support systems (brochures and hotline) are important but in their present form were not effective. With modifications, such as a revision and better distribution of the brochures, these systems could enhance the effectiveness of the RSIS. Even with limited brochure and hotline access, 3,000,000 readings were delivered to over 1,000,000 different vehicles.

CHAPTER I INTRODUCTION

The Intelligent Transport Systems (ITS) Operational Test project was sponsored by the U.S. Department of Transportation(USDOT)/Federal Highway Administration (FHWA) in conjunction with the Colorado Department of Transportation (CDOT) and its partners, Conoco, Inc., Remote Sensing Technologies, Inc. (RST), Skyline Products, Inc. the University of Denver (DU), and the Colorado Department of Public Health and the Environment (CDPHE). The independent evaluation was conducted by the National Center for Vehicle Emissions Control and Safety (NCVECS) at Colorado State University (CSU). The project addressed the potential of ITS to support cleaner air by providing real-time vehicle tailpipe emissions information (carbon monoxide levels) to the driving public. It made an appeal to the driving public to accept responsibility for maintaining their vehicles, to increase gas mileage and minimize harmful tailpipe emissions.

Air quality has been a concern of informed citizens, and state and federal agencies for decades. Technology forcing legislation has compelled auto manufacturers to cut emissions and increase fuel economy. The Clean Air Act Amendments (CAAA) of 1990 are one such form of technology and regulatory forcing legislative mandates. In response, many states have implemented a mandatory vehicle emissions inspection and maintenance (I/M) program.

Federal, state and local officials are struggling to bring their non-attainment urban areas into compliance with the requirements of the CAAA. Their efforts are confounded somewhat by the continued growth of vehicle miles traveled (VMT) A second form of legislation aimed at reducing emission and increasing fuel economy is the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). ITS is a response to this legislation. ITS aim at the reduction of environmental and energy impacts of surface transportation (CDOT 1994).

It has been shown that a small percentage of the vehicle population is responsible for half of the vehicle emissions (Bishop et al. 1989, Bishop and Stedman 1990). These high-emitting vehicles have been shown to need tuneups or repairs (Bishop et al. 1993, Octane Week 1993). New systems are needed to supplement the existing programs in locating these high emitting vehicles and bring their vehicle emissions into compliance. One potential system might be the use of the ITS.

PROJECT BACKGROUND

The main purpose of this project was to create, test, and evaluate the effectiveness of ITS technology in enhancing the driving public's awareness and responses to the real-time emissions information it provides to vehicle operators. How effectively was awareness raised and did motorists assume responsibility for their polluting vehicles?

The operational test project consisted of the installation of an ITS system at an interstate freeway off-ramp in Denver. The ITS system, a Remote Sensing Information System (RSIS), included a Remote Sensing Device (RSD) that measures real-time tail pipe carbon monoxide (CO) emissions from passing vehicles, a Variable Message Sign (VMS) that immediately presents the CO emissions levels to motorists, and auxiliary support information services such as a telephone information hotline and brochures that provided motorists with information concerning the project (see Appendix D).

The RSIS system was operated in real-time, 24 hours a day, during the project and was at a fixed location at the southwest quadrant loop ramp of I-25 and Speer Blvd. This site consisted of a tightly curved uphill loop ramp which carries traffic from the I-25 corridor into downtown Denver (Figure 1). Each vehicle using this freeway off-ramp had its exhaust monitored (via RSD) at the bottom of the ramp and the results were displayed via the VMS at the top of the ramp at the optimum viewing angle for the motorists .

The RSD is an application of a technology that can be used to monitor on-the-road vehicle emissions (Figure 2). It is an instrument based on non-dispersive (NDIR) infrared (IR) technology. An IR beam is directed across one lane of traffic, about 10 inches above the pavement, into an assembly containing detectors for CO, HC, CO₂, and a reference detector. An optical filter that transmits IR light of a wavelength known to be uniquely absorbed by the molecule of the interest gases, is placed in front of each detector. This determines detector specificity. Reduction in the signal caused by absorption of light by molecules of interest is translated and recorded by a computer into individual tailpipe concentrations. Prior research of the technical feasibility of using the remote sensing device (RSD) for vehicle emissions monitoring has validated the accuracy of its readings at + or -5% for instantaneous (0.5 seconds) carbon monoxide (CO) emissions. Over four million vehicle emissions measurements have been made in RSD studies around the world.

Several studies of the RSD, conducted primarily by the University of Denver, have shown that when emissions information is provided to the motorist within a few days of its measurement, 45% of the motorists can be persuaded to act on that information with resultant reductions in CO emissions of 47% and increases in fuel economy of 12% (Stedman et al, 1988 and Bishop et al, 1993).

Central to the project was the design of the message sign (Smart Sign) and the information it conveyed to motorists. The sign provided a real-time read out of carbon monoxide from the RSD to each motorist exiting from the freeway (Figure 3). The sign design and the display of information was reviewed by three focus groups (see Appendix E), in the early stages of the project. The first focus group was comprised of information experts and the second two were comprised of a representative mix of the general public, one comprised of males and one comprised of females. The focus groups were extremely important in providing initial feedback on the effectiveness of the information that the sign displayed.

The sign's information was augmented by:

- (1) a telephone hotline;
- (2) program brochures; and
- (3) news media coverage.

The telephone hotline, operated by DU, answered questions and recorded comments and attitudes expressed by the callers concerning the RSIS. A brochure (see Appendix D) providing additional information was sent if requested. The brochure provided information about the program and gave maintenance suggestions for reduced vehicle emissions. The brochures were available at area Conoco service station/convenience stores, through the hotline, and were sent to a sample of drivers passing the sign. The auxiliary sources of information combined to inform and educate the public that operating a gross polluting vehicle is bad not only for the environment but also, because of poor fuel economy, for their pocketbook.

PROJECT OVERVIEW

The project consisted of three phases (Workplan 1994):

- | | |
|-----------|---|
| Phase I: | Installation of the RSD and emissions measured and license plate numbers logged without advising motorists of the information. The VMS was designed, constructed and integrated with the remote sensing monitoring equipment. Program brochures were designed for distribution. |
| Phase II: | Installation of the VMS and integration with the RSD. Measurement and recording of emissions were continued and information became available via the VMS to the motorists concerning their vehicle tailpipe emissions. Evaluation of the accuracy of the combined technology of the RSIS system began. Compilation of a database of selectively sampled vehicles by using the license plate reader began. The telephone information hotline began operation and the program brochure became available. A press conference was held at the site demonstrating the RSIS. News items were released. (See Appendix D) |

Phase III: Motorists were surveyed to evaluate their response to the influence of the project sign, the hotline, brochures, and information distributed by the media. Random checks of the remote sensing system were continued to verify systems accuracy. The results were analyzed and the final report was written.

The project organizational structure consisted of a team from DU who were responsible for installing and maintaining the RSD and the VMS at the Speer Blvd. I-25 off-ramp. The DU team was also responsible for conducting focus groups to help determine the most appropriate and effective message for the VMS and for monitoring the hotline. CDOT, under the direction of the Federal Highway Administration (FHWA), Colorado Division, helped address the design and implementation of the RSIS. An independent evaluation of the ITS Operational Test Project was conducted by the NCVECS at CSU.

PROJECT GOAL:

To promote the deployment of intelligent transportation technologies, specifically the instantaneous delivery of data supplied by remote sensing, in an effort to realize the benefits of reduced vehicle fuel consumption, increased vehicle operating efficiency, and increased support of improved air quality (Workplan 1994).

PROJECT OBJECTIVES:

1. To merge existing and commercially available technologies into a new on demand/emissions information tool which will provide real-time vehicle emissions information to the driving public.
2. To educate the public that a well tuned vehicle is the most cost-effective means to obtain and maintain clean air. That repairing inefficiently operating vehicles (high emitters) will pay for itself in fuel cost savings alone.
3. To encourage the public to voluntarily have their vehicles tested often and quickly act on the information to catch maintenance problems early.
4. To demonstrate the usefulness and public acceptance of this approach for reducing harmful emissions, and show its applicability to the national ITS program for use in other locations (Workplan 1994; CDOT 1994).

CHAPTER II PROJECT EVALUATION

INTRODUCTION

The project evaluation was conducted by NCVECS at CSU. The evaluation team consisted of technical experts with many years experience with the RSD and with social scientists with many years experience conducting emissions surveys in both the United States and Mexico. The evaluation project took place from January to December of 1996 (see Table 1).

Table 1 - ITS Project Evaluation Timeline

1996	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
QUESTIONNAIRE DEVELOPMENT												
RSIS												
QUESTIONNAIRE PRE-TEST												
SIGN												
BROCHURES												
QUESTIONNAIRE SURVEY												
CASE STUDIES												
DATA ANALYSIS												
DRAFT EVALUATION REPORT												
FINAL EVALUATION REPORT												

EVALUATION GOAL:

To assess the technical ability of the RSIS to provide emissions data and to assess the driving publics' response to voluntary information.

EVALUATION OBJECTIVES:

1. To determine the efficiency and effectiveness of the integration, implementation, and operation of the various equipment components of the RSIS.
2. To determine if the RSIS delivered accurate tailpipe emissions information to the driving public.
3. To assess how the information was received, processed, and responded to by the driving public.
4. To assess the extent to which the driving public became educated regarding the need for regular vehicle maintenance.

EVALUATION APPROACH

The evaluation used a multi-method approach to measure the technical ability of the RSIS in disseminating emissions information and to assess the behavioral response of the driving public to the RSIS.

PROJECT COMPONENTS:

COMPONENT I: TECHNICAL - Verifying the accuracy of the technical system by addressing:

- 1) Did the RSIS work (the combination of RSD and VMS technology)?;
- 2) Were the motorist's emissions being accurately measured and reported?; and
- 3) Was the correct information displayed to the appropriate motorist? Component I addressed Evaluation Objectives 1 and 2.

COMPONENT II: BEHAVIORAL - Evaluating the effectiveness of the information sources on motorists' response levels by attempting to answer:

- 1) Did it influence awareness of emissions levels?
- 2) Did it influence knowledge of the relationship between emissions, maintenance/repair and fuel economy?
- 3) Did it influence intentions to respond to the emissions information such as repairing the vehicle? and
- 4) Did it influence the motorists to actually do anything (action) in response to the sign? Component II addressed Evaluation Objectives 3 and 4.

RESEARCH DESIGN

The evaluation took place in three stages:

- Stage I: **BASELINE DATA COLLECTION.** Baseline emissions data collected before the sign was installed were analyzed. License plate data captured via digital camera were sorted to identify vehicles used in the sample selection for Component II of the Evaluation. Evaluation of the combined technology of the RSIS took place.
- Stage II: **DATA COLLECTION.** Emissions data continued to be collected and analyzed after the sign was installed. Surveys and case study interviews were conducted. Auxiliary systems, the telephone hotline and the information brochure, were assessed for their usefulness. Evaluation of the RSIS continued to take place.
- Stage III: **DATA ANALYSIS AND REPORT WRITING.** Emissions data continued to be checked for accuracy. The various motorists responses from awareness to action were analyzed. The Statistical Package for the Social Sciences (SPSS) was used for the analysis. Selected case studies were written emphasizing exploratory data. The evaluation team produced progress reports and a final report.

METHODOLOGY

COMPONENT I - THE TECHNICAL COMPONENT:

1. Covert vehicles were periodically driven through the RSIS. These vehicles were equipped with a portable “in flight” CO analyzer capable of directly monitoring the covert vehicles’ exhaust as it is driven through RSIS. By adjusting the vehicles’ CO to levels known to be associated with the various VMS displays, the overall response of the RSIS was evaluated for both correctness of display message and readability. Different ambient conditions such as weather, wind, dust, snow, and rain were noted.

Emission data were checked for accuracy and analyzed and categorized according to low, average and high emissions. An assessment was made of the reliability and effectiveness of the RSIS to provide emissions data.

2. RSIS down-time occurrences were periodically audited.

COMPONENT II - THE BEHAVIORAL COMPONENT

A randomly selected sample of motorists of remote sensed vehicles were surveyed to assess their perceptions and responses to the message sign and its support systems. Case studies were conducted within a subset of this group to provide in-depth information and insights into behavioral perceptions and responses to the message sign.

License plate data were captured automatically via an unmanned digital camera. The license plate reader (LPR), part of the remote sensor system, provided license numbers corresponding to the CO readings. The information was used to identify motorists for the survey sample needed for Component II. The survey sample was dependent upon the capabilities of the license plate reader (Appendix C). The license plate reader takes a strobe picture and sends it to the computer. The computer sorts for the license plate and prints the plate number. The license plate reader was used only to track data for users of the ramp.

The sample was identified from the population of motorists driving from southbound I-25 to the eastbound Speer Boulevard off-ramp in Denver, Colorado. Prior studies at the site show that roughly 500 motorists per hour drive on the off-ramp. The sample was stratified into three groups according to the CO readings from the Remote Sensor:

1. motorists with high emission readings ($>4.51\%$ CO)* - POOR readings (high polluters);
2. motorists with average emissions readings ($4.5 - 1.31\%$ CO)* - FAIR readings (border-line polluters); and
3. motorists with low emission readings ($<1.3\%$ CO)* - GOOD readings (low polluters).

*Basis for these cut points discussed in Appendix C.

As described in the brochure, the three categories were designed so that all 1983 and newer cars should read GOOD while some older model year vehicles were designed to obtain FAIR readings. A POOR reading indicates a vehicle in need of repair regardless of age.

A probability sample of 474 motorists, given an error rate of less than 3 percent per stratum, was selected from the vehicles driving through the site at various hours of the day and days of the week. Ninety-five percent confidence intervals were calculated for all the estimates of percentage responses on key variables. The original sample was to include up to 800 motorists divided into the three strata. It was not possible to survey 800 motorists due to the cost of the interviews, the low number of cars in the poor stratum (only 4 to 5% of the fleet of cars driving past the sign), and the refusals of some motorists, especially those in the poor stratum, to be interviewed. The sample of 474 vehicles was analyzed in the aggregate and according to the three strata (Babbie 1989, Bernard 1995).

Survey data were collected by telephone interviews lasting 10 to 14 minutes (Questionnaire in Appendix A). The surveys were conducted for each stratum during the first six months that the RSIS was in operation. The intent of the interviews was to assess the influence of the sign on the motorists' awareness, knowledge and behavior.

Statistical analyses were done on the surveys using the Statistical Package for the Social Sciences (SPSS). The analysis compared and contrasted the various motorists' response levels to the RSIS from awareness. Comparison was made of the aggregate survey population and between the three strata with poor, fair and good readings. Univariate analysis was used to make these comparisons and to describe the population.

A small sub-sample of 20 motorists from the telephone survey was interviewed. An attempt was made to select a random sample from all three strata, but due to the logistics discussed above it was not consistent. In-depth interview techniques were used to collect explanations of perceptions and responses to the RSIS. Case study data were collected by personal interviews (Complete case studies and protocol are in Appendix B).

A brochure describing the project was distributed by Conoco at their Mini-marts and was available to those calling the project hotline (Brochure in Appendix D). Brochures were also sent to one half of the telephone interview sample for all three strata before the initial interviews were conducted.

The assessment of the usefulness of the auxiliary support systems was done by including questions in the questionnaires on the influence of these systems on the perceptions and responses of the survey participants.

Reports consisted of an evaluation plan, progress reports and the final project report. This final report addresses the effectiveness of the project in achieving its stated goal and objectives.

RESULTS

COMPONENT I - TECHNICAL COMPONENT

1. Four vehicles were used to conduct a series of drive throughs at the sign. The vehicles were instrumented with an OTC (Owatonna Tool Company) "in-flight" 5 gas portable emissions analyzer. The analyzer was set-up and calibrated in the vehicle and the sample hose was connected to the tail pipe. The CO readout was used in an attempt to compare the vehicle's emissions with the sign's message. One of the vehicles (a 1986 Chevrolet Celebrity) was equipped with a device to vary the CO emissions from the tailpipe; the other vehicles relied on a speed/load variation by the motorist to induce different tailpipe percent concentrations of CO emissions.

The OTC analyzer has a published accuracy of plus or minus 3% of full scale 10% CO. This means that the analyzer itself can resolve a 3% CO measurement to 3% plus or minus .3% or 2.7% to 3.3%. The OTC analyzer also has a data logger such that up to several minutes of data can be recorded for later review. This feature was used in most of the drive throughs.

Typically, the vehicle was driven through the sign's remote sensor a number of times in a manner similar to a motorists' pattern in using the exit ramp. The sign's message: GOOD, FAIR or POOR was noted along with the OTC's CO measurement in percent. An allowance was made for analyzer transport time (6-7 seconds). Comparisons could then be made knowing the sign's "threshold" levels in CO percent corresponding to GOOD (<1.3% CO), FAIR (4.5 - 1.3 1% CO) & POOR (>4.5 1% CO).

The data suggest no observable malfunctions in the sign's ability to report the correct category of vehicle CO emissions: GOOD, FAIR, or POOR. It should be noted that instantaneous variability in CO emission concentrations at the tailpipe can be very large. Indeed, the OTC data logger showed instantaneous fluctuation of plus or minus 3%. The vehicle's computer and interactions with the fuel metering as well as catalytic converter effects are suspected as having caused much of this variability.

These drive throughs were only spot checks. The drive throughs were covert, however, and no sign down-times were experienced in this study. Different ambient conditions such as weather, wind, dust, snow, and rain were noted.

2. RSIS down-time occurrences were periodically audited. Down-time can be caused by weather, especially rain or snow, accidents, equipment failure or unforeseen events. The percent down-time per month was as follows: (Table 2)

Table 2 - RSIS Downtime

Month	Monthly Hours (Down-time-Hours) percent Down-time	Comments
May 16 (start date) - May 31	384 hours (114) 30%	Weather related and start up problems
June	720 hours (33) 5%	
July	744 hours (33) 11%	Electrical problems with detector start

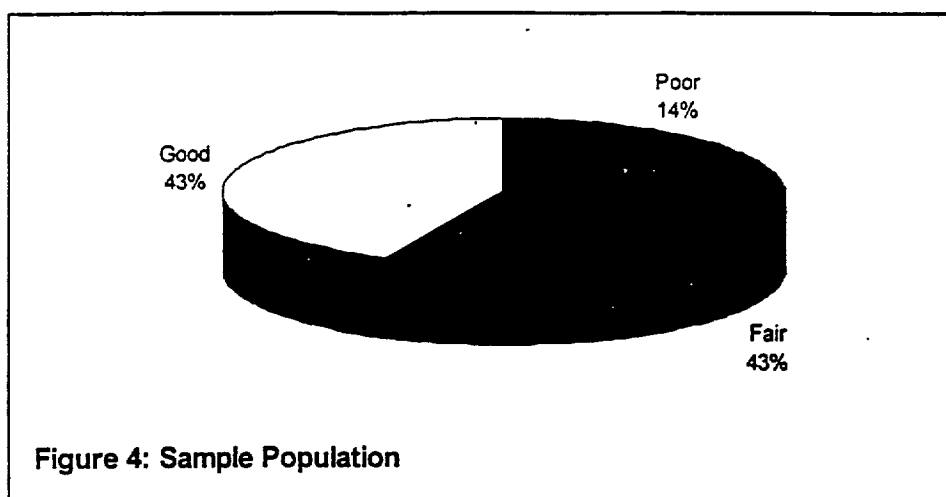
Month	Monthly Hours (Down-time Hours) Percent Down-time	Comments
September	720 hours (53) 7%	Software upgrade to detect and restart after detector failure.
October	720 hours (67) 12%	57 hours of operation lost due to local construction interrupting power.
November	720 hours (39) 5%	
December	720 hours (217) 32%	181 hours of operation lost due to local construction interrupting power.

COMPONENT II - BEHAVIORAL COMPONENT

SAMPLE POPULATION

A randomly selected sample of motorists of remote sensed vehicles were surveyed to assess their perceptions and responses to the Smart Sign and its support systems. The sample was divided into three strata representing those vehicles with poor, fair, and good emissions readings. An attempt was made to interview up to 800 motorists as discussed in the Evaluation Plan (Bohren 1996a). It was not possible to interview 800 motorists equally divided into the three strata due to the high cost of interviewing, time constraints, the low number of cars with poor readings (approximately 4 to 5% of the cars passing the sign), and the high number of refusals in the poor category.

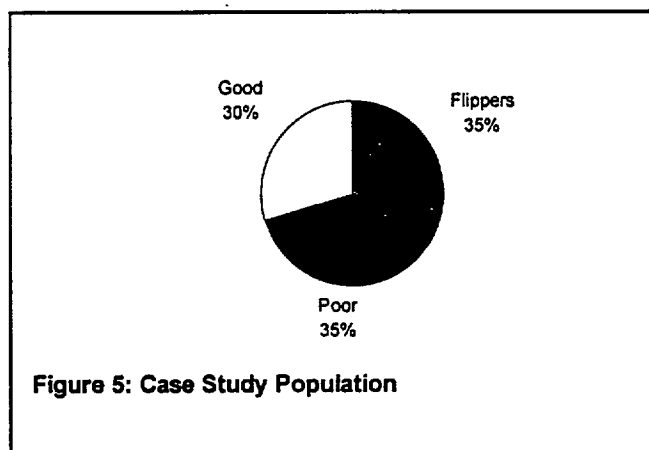
The sample population was 474: 14% (68) poor, 43% (205) fair, and 43% good (201). (Figure 4)
The sample population was comprised of 55% (261) males, and 45% (213) females.



Case studies were conducted within a subset of the sample to provide in-depth information and insights into behavioral perceptions and responses to the message sign (see Appendix B for complete case studies). The sample of 20 case studies were divided into the following categories (Figure 5):

35% (7) in the poor category;
30% (6) in the good category; and
35% (7) had readings that varied between categories (flippers):
20% (4) in a good and fair category;
10% (2) in a good and poor category; and
5% (1) in a good, fair, and poor category.

The case study sample was made up of 15 (75%) males and 5 (25%) females.



WEIGHTED POPULATION

In order to normalize the fleet of cars passing the sign, the analysis of the aggregated sample fleet (14% poor, 43% fair, and 43% good) was recalculated (weighted) to represent the proportion of vehicles with poor, fair, and good readings in the total overall fleet passing the sign (4% poor, 10% fair, and 86% good). (Figure 6)

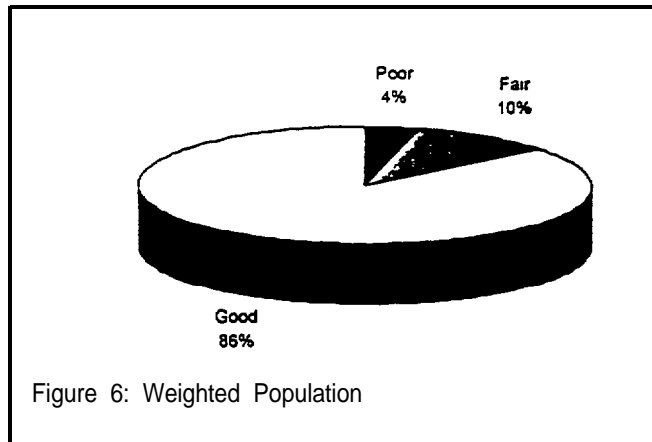


Figure 6: Weighted Population

The total number of unique vehicles sampled from the 3,000,000 measurements was obtained from the survey results. The 474 telephone survey participants reported that they were responsible for about 5,300 readings. From these data we predict that there have been $3,000,000 \times 474/5300 = 232,200$ unique vehicles passing the RSIS.

The weighted population was characterized as being 51% male and 49% female. (Figure 7)

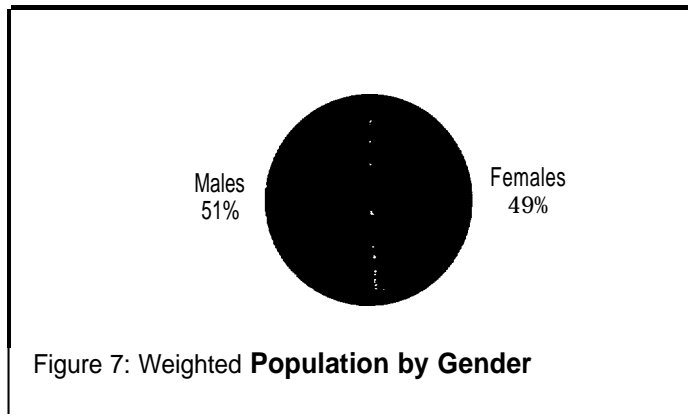


Figure 7: Weighted Population by Gender

In the following report, the weighted calculations that represent the proportions of the overall fleet will be the basis for the analysis.

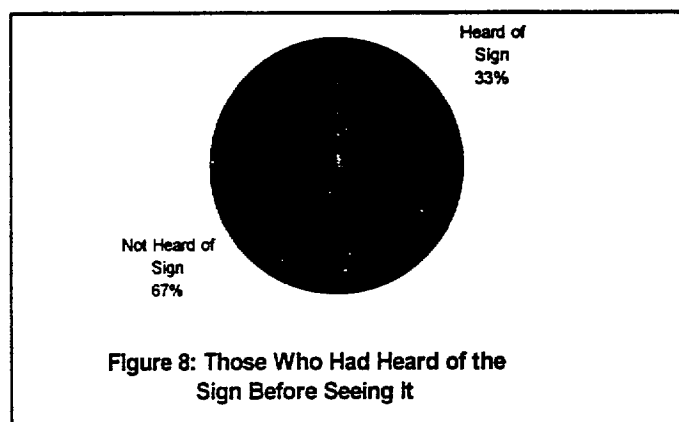
EFFECTIVENESS RESPONSE CATEGORIES

The phone survey questionnaire was designed to evaluate the effectiveness of the information sources on motorists' response levels by attempting to answer:

- 1) Did it influence awareness of emissions levels?
- 2) Did it influence knowledge of the relationship between emissions, maintenance/repair and fuel economy?
- 3) Did it influence intentions to respond to the emissions information such as repairing the vehicle? and
- 4) Did it influence the motorists to actually do (action) anything in response to the emissions information?

1. AWARENESS

Thirty-three percent of the weighted population remembering the sign had heard of it before passing it. (Figure 8)



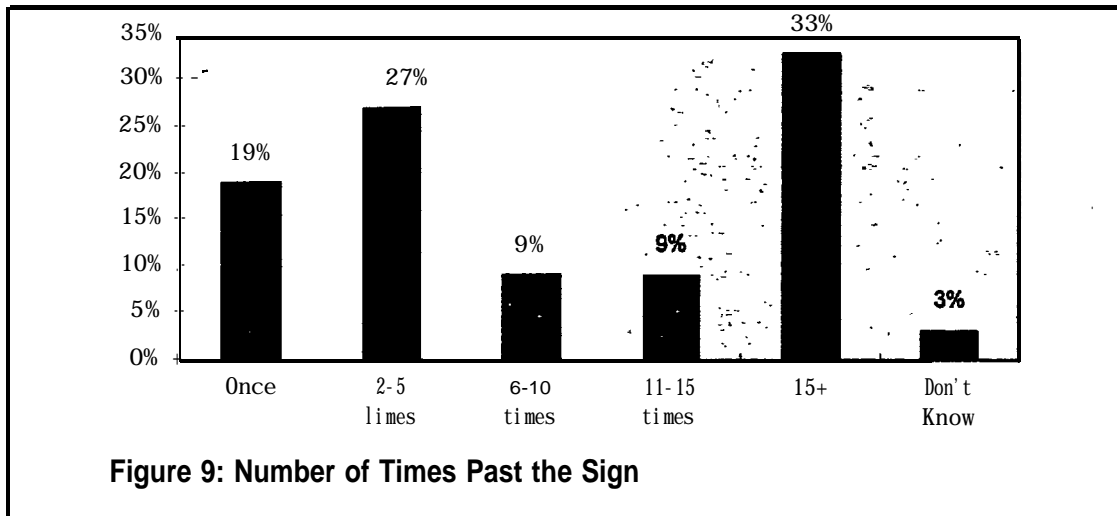
The analysis of the data by stratum shows that approximately one-third of the poor, one-third of the fair and one-third of the good strata had heard of the sign before seeing it. (Table 3)

Table 3 - Percent of Those Who Had Heard of the Sign Before Seeing It Within Stratum

Response	Poor	Fair	Good
Yes	31	33	33
No	69	67	67

Twenty-six percent of the weighted population had heard about the sign from the media, 4% from others who had driven past the sign, and 1% from the brochure.

Nineteen percent of the weighted population said they had driven the same car past the sign only once, while 33% said they had driven the same car past the sign 15 or more times. (Figure 9) Eighty percent of the weighted population had driven past the sign multiple times.



The analysis of the data by stratum shows that the poor and fair strata had driven the same car past the sign the fewest number of times. The poor stratum had the highest percentage (38%) of cars drive past the sign 2 to 5 times; the fair stratum had the highest percentage (34%) of cars drive past the sign one time; and the good stratum had the highest percentage (35%) of cars drive past the sign 15 or more times. (Table 4)

Table 4 - Number of Times Past the Sign Within Stratum (Percentages)

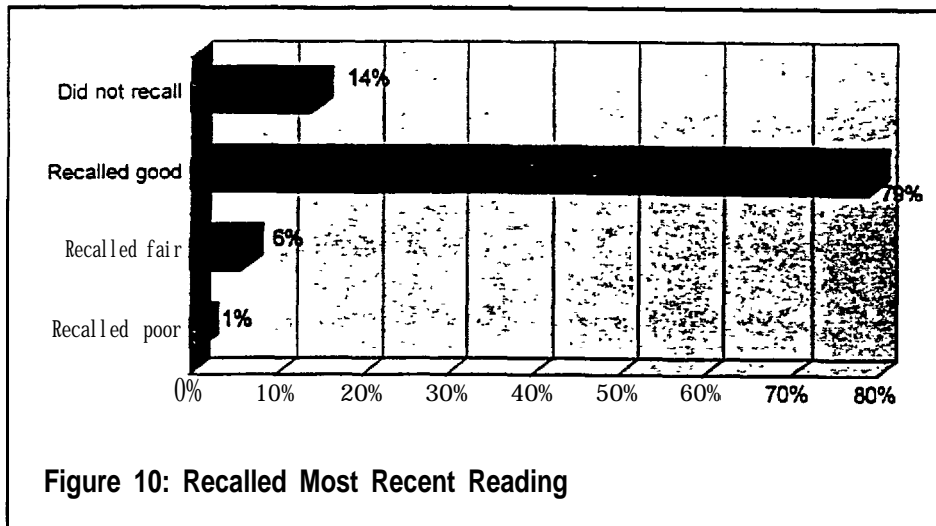
Number of times past sign	Poor	Fair	Good
Once	18	34	17
2-5	38	26	26
6-10	9	10	9
11-15	9	4	10
15+	24	24	35
Don't Know	3	2	4

The weighted population's recall of the most recent reading on their car was: 1% recalled poor, 6% recalled fair, 79% recalled good, and 14% did not recall their most recent reading.

(Figure 10) This finding

demonstrates that

recall was not consistent with the number of vehicles per stratum.



The analysis of the data by stratum shows that those in the poor stratum had the worst recall while those in the good stratum had the best. (Table 5)

Table 5 - Percent Who Recalled Most Recent Reading Within Stratum

Reading Recalled	Poor	Fair	Good
Poor	28	2	0
Fair	22	40	1
Good	29	36	87
Don't Know	21	22	12

The case study sample was asked what they remembered about the sign. Most of the people in the poor category recalled a poor reading. One who claimed to have driven past the sign hundreds of times, remembered seeing all three readings. The one in the poor category who did not recall getting a poor reading claimed to have been by the sign twice in three months and said, "It was saying you're in good health or you're tuned up or something to that effect." Most of the people in the good category remembered a good message. The one who did not remember seeing a good message, remembered the saving you money message and was happy about that message. A person in the good category who recalled seeing a good message, was not sure if the reading was for him or the person in front of him. Most of the flippers who got both a good and a fair reading remembered both readings. The other flipper only remembered the good reading. One of the two who received both a good and poor reading remembered both readings. This

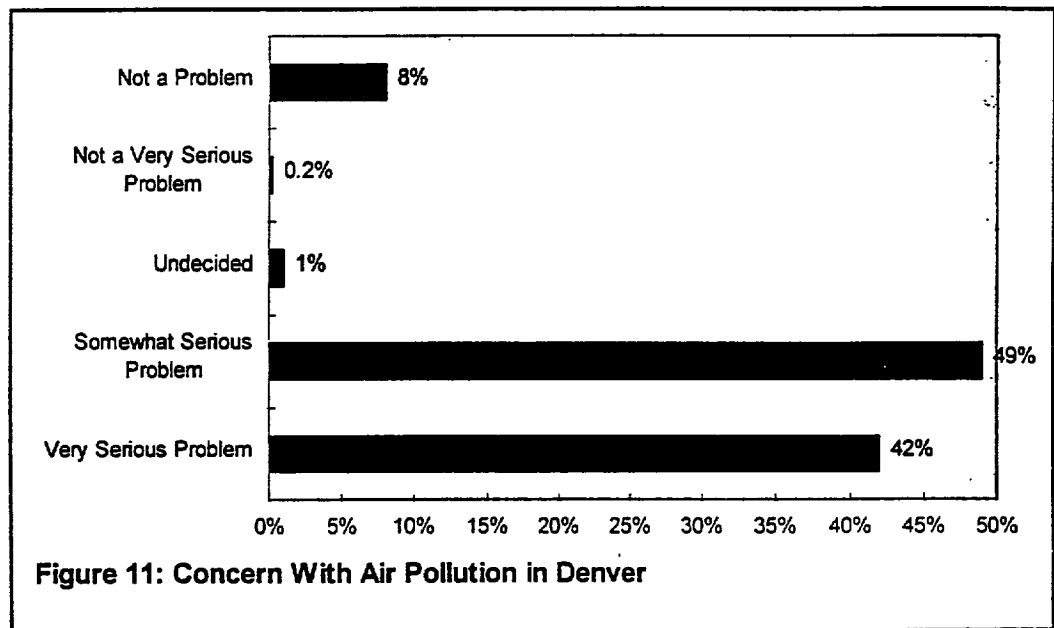
same person worked on his car after receiving the poor reading. The one who didn't remember the poor reading, mentioned that the good message is useful to confirm that "you're doing ok". The person who received all three readings recalled all of the messages. In general, the case study sample remembered their readings better than the telephoned population.

Approximately one-third of the weighted population had heard of the sign before driving past it. Eighty percent of the cars had driven past the sign more than once. The drivers of the cars in the good stratum were more likely to recall the correct reading (87%) while the drivers of cars in the poor stratum were the least likely (28%). Sixteen of the 20 (80%) case study participants remembered the correct reading as reported by the Smart Sign.

2. KNOWLEDGE

The motorists were asked what the major environmental problems were in Denver. The number one environmental problem in Denver, according to the weighted population was growth; the second was air pollution. All three strata, poor, fair, and good, agreed that growth was the number one environmental problem.

Questions were asked establishing the respondents concern with air pollution in Denver. Ninety-one percent of the weighted population believed that air pollution in Denver is a serious problem (42% very serious). Less than 1% believed it was not a problem and 1% were undecided. (Figure 11)

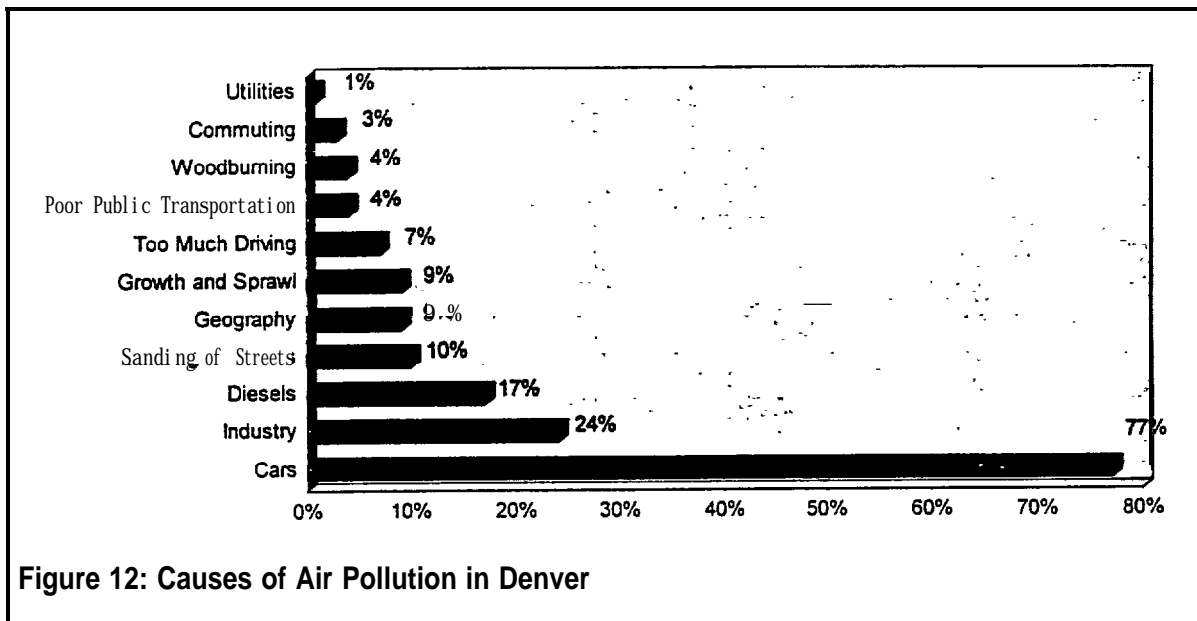


The analysis of the data by stratum showed that those in the good stratum felt it was more important than those in the fair and poor strata, in that order. (Table 6) Women tended to feel it is a more serious problem than men.

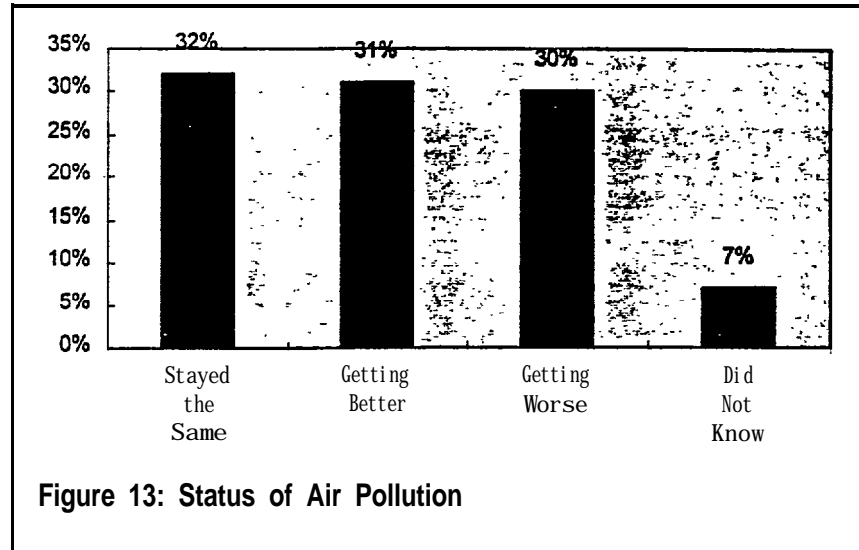
Table 6- Concern with Air Pollution in Denver within Stratum (Percentages)

Concern	Poor	Fair	Good
Very Serious Problem	41	39	42
Somewhat Serious Problem	43	53	49
Undecided	2	1	1
Not a Very Serious Problem	12	6	9
Not a Problem	3	1	0

The weighted population's response to the causes of the air pollution problem in Denver (more than one could be listed) was.: the number one cause (77%) was cars followed by industry (24%) and then by diesels (17%). (Figure 12) It is interesting to note that 80% of the CO pollution problem in Denver is attributed to mobile sources (CDPHE).



When asked whether the air pollution problem was getting better or worse in the past 5 years, approximately 1/3 of the weighted population felt it was getting worse, 1/3 felt it had stayed the same, 1/3 felt it was getting better, and 7% did not know. (Figure 13)



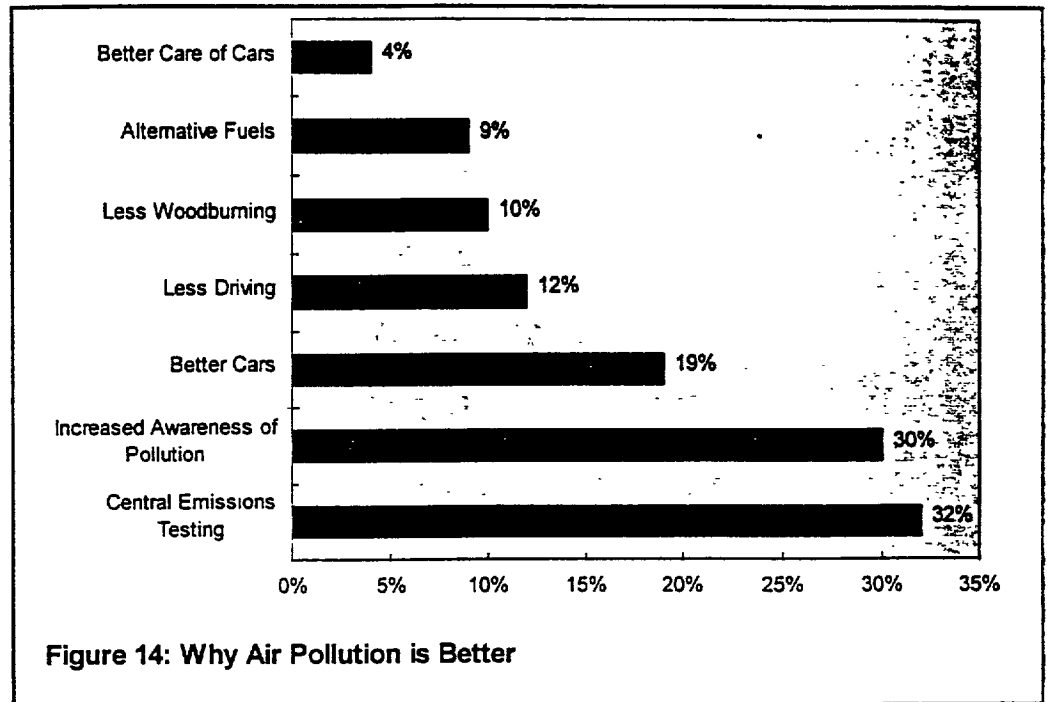
The analysis by stratum found that there were more in the poor stratum who felt the air pollution problem in Denver was getting better, more in the fair stratum who felt it was getting worse, and more in the good stratum who felt it was the same. (Table 7)

Table 7 - Status of Air Pollution Within Stratum (Percentages)

Status	Poor	Fair	Good
Better	35	24	31
Worse	25	37	29
Same	34	33	32
Don't Know	6	7	8

Of those in the weighted population who felt air pollution was getting better, the most frequent reason (more than one could be listed) was central emissions testing (32%), second was increased awareness of pollution (30%), and the third was better cars (19%). (Figure 14) The influence of central emissions testing and increased awareness of pollution on improved air quality in Denver are seen by approximately one-third of the

population as being of equal importance. It is interesting to note that more emphasis is placed on technology (better cars, 19%) than on behavior (better care of cars, 4%).

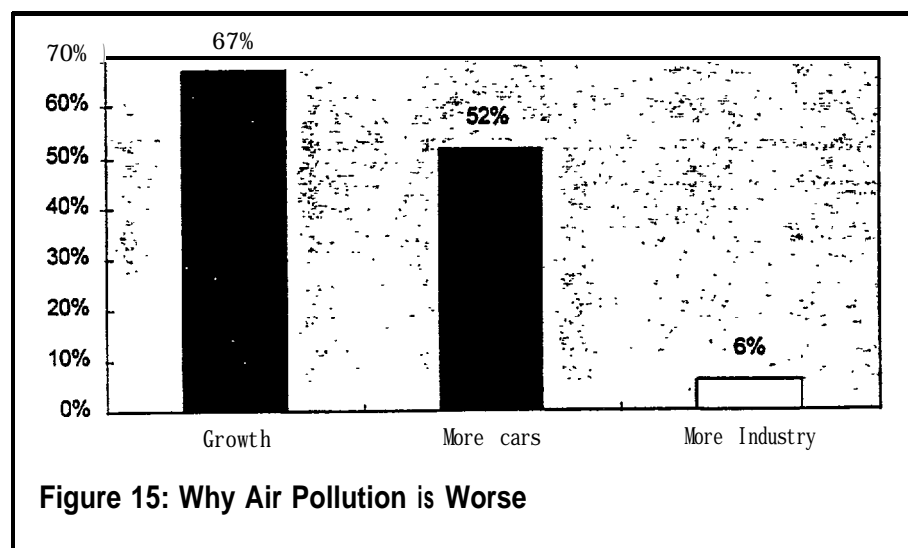


The analysis of the data by stratum found that of those who felt that air pollution was getting better, more in the poor stratum felt that it was due to an increased awareness of air pollution, more in the fair stratum felt it was due to the central emissions testing, and more in the good stratum felt it was due to central emissions and an increased awareness of air pollution. In all strata better cars seemed to be more of a contributor to better air quality than better care of cars, although more in the poor stratum felt better care of cars was important. (Table 8)

Table 8 - Why Air Pollution is Better Within Stratum (Percentages)

Why	Poor	Fair	Good
Central Emissions Testing	25	41	32
Better Cars	25	27	18
Use of Alternative Fuels	13	7	10
Less Woodburning	13	10	10
People Driving Less	4	6	13
People Taking Better Care of Cars	17	8	3
Increased Awareness of Pollution	33	22	30
Other	17	20	16

Of those in the weighted population who felt air pollution was getting worse, the most frequent reason (more than one could be listed) was growth (67%) followed by more cars (52%). (Figure 15)

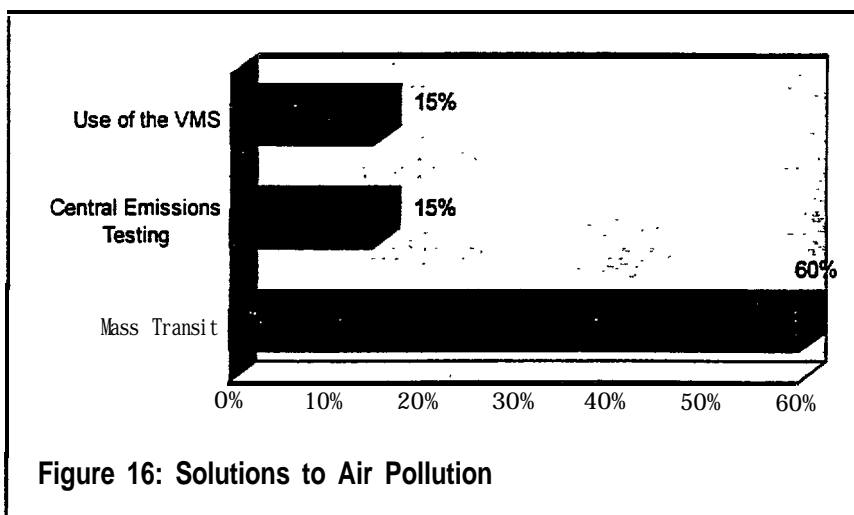


The analysis of the data by stratum found that more in all three strata felt air pollution was getting worse due to population growth; more cars was a close second. (Table 9)

Table 9 - Why Air Pollution is Worse Within Stratum (Percentages)

Why	Poor	Fair	Good
More Cars	47	49	53
Central Emissions Testing	0	1	0
Population Growth	88	68	66
More Industry	12	8	5
Other	6	15	10

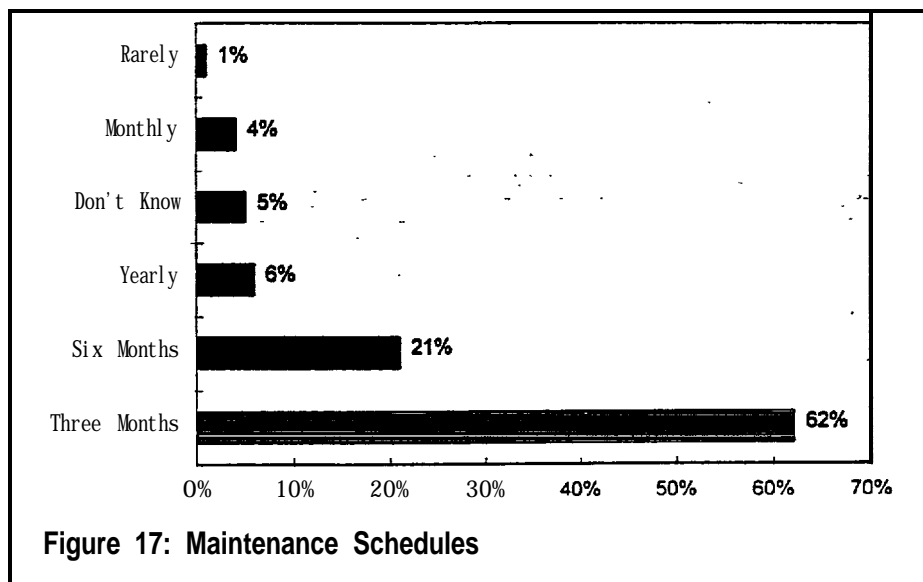
The case study sample was asked for suggestions for solutions to the air pollution problem (they could choose more than one). Nineteen of the 20 (95%) had one or more suggestions. They were: mass transit 12 (60%) if improved, central emissions testing 3 (15%), and the use of the Smart Sign 3 (15%). (Figure 16)



One case study participant with a poor reading stated he would like to “have mass transit as an option.” He feels he would use it but that he can’t rely on mass transit when he works odd hours. Another motorist with a poor reading who suggested mass transit as a solution. said, “you’re talking about an additional hour and a half on my day if I use the bus, but.” when questioned about rail as a public transit system, he replied, “you have a whole different ball game, rail saves you time.” He went on to say that he could work on a train, i.e. that he gains time on rail whereas it costs him time on a bus. A respondent with a good and poor reading said he would pay \$50 dollars a month for light rail if it were easily accessible. A respondent with a poor reading claimed, “mass transit is a real solution, it is the solution. How that’s funded is another set of works, convenience is the height of the issue.” A motorist with a good and fair reading said, “I’d like to take a bus to work, but my job requires me to go from place. I wish more people could take the bus.” A motorist who received a good and poor reading, suggested the use of the VMS as a solution to the air pollution problem. He suggested we, “put the signs all over the place, it makes people aware.” A response by a motorist with a poor reading was, “I hope the end result is that we end up with a passive system instead of going down to Envirotest, so I hope you get your signs and your passive things and someday I’ll get caught.” A motorist with a good reading said, “I think things like this, letting people know about their car’s problems.” The case study sample was very favorable toward mass transit, especially rail. They felt a combination of the VMS and central emissions testing would be a good approach toward solving the air pollution problem in Denver.

To establish knowledge of the relationship between emissions and maintenance/repair, we asked about car maintenance. The statement that “a well-maintained car can reduce air pollution,” was made. Ninety-nine percent of the weighted population agreed (89% strongly agreed) with this statement.

The weighted population was then asked about their maintenance habits. Sixty-two percent of the motorists said they maintained the car that was driven past the sign every three months (the manufacturers suggested time) while 21% said they maintained it every six months. (Figure 17)

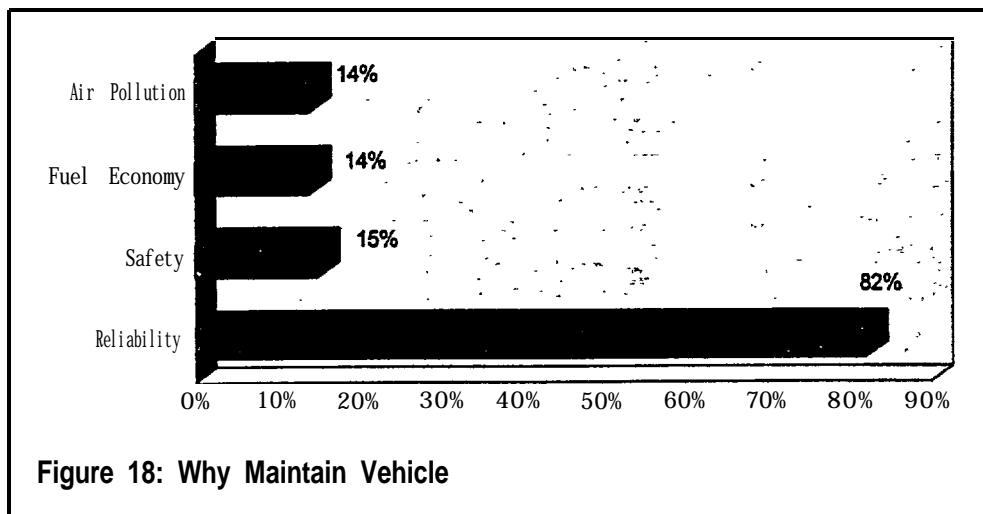


The analysis of the data by stratum found that there were more in all three strata who maintained their cars every 3 months as recommended by car manufacturers and very few who rarely maintained their cars. (Table 10)

Table 10 - Maintenance Schedules Within Stratum (Percentages)

Schedule	Poor	Fair	Good
Monthly	9	8	4
3 Months	41	51	64
6 Months	34	25	20
Yearly	7	13	6
Rarely	3	1	1
Don't Know	6	2	6

When asked why they maintained their cars (they could give more than one reason), the weighted responses were: reliability (82%), safety (15%), fuel economy (14%), and air pollution (14%). (Figure 18)



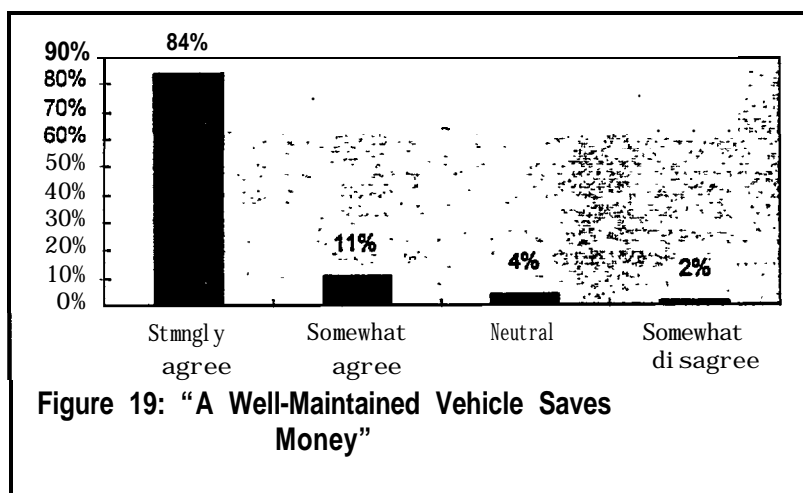
As a comparison, a previous study of motorists in El Paso, Texas and Juarez, Mexico also found that reliability was the primary reason (73%) for maintenance. Air pollution, however, was the second most important reason (12%), for Juarez residents while El Paso residents felt that fuel economy was second (8%). Safety was the fourth reason (3%) for both cities (Bohren, 1996b).

The analysis of the data by stratum found that all three strata (especially the poor stratum) agreed that reliability was the primary reason for maintaining their vehicles. The poor stratum felt safety was the second most important reason for maintenance while the fair stratum felt safety and fuel economy were close seconds. The good stratum was equally split between the other categories. (Table 11)

Table 11 - Why Maintain Vehicle With in Stratum (Percentage)

Why	Poor	Fair	Good
Safety	25	22	13
Reliability	90	74	82
Air Pollution	15	17	13
Fuel Economy	15	21	13
Other	6	17	14
Don't Know	3	2	2

To establish knowledge of the relationship between maintenance/repair and fuel economy, the weighted population responded to the statement “a well-maintained vehicle actually saves money”. The results were as follows: 95% agreed with the statement (84% strongly), 2% disagreed with the statement (none strongly), while 4% were neutral to the statement. (Figure 19)



The analysis of the data by stratum found that all three strata strongly agreed with the statement. (Table 12)

Table 12 - “A Well-Maintained Vehicle Saves Money” Within Stratum (Percentages) II

Response	Poor	Fair	Good
Strongly Agree	63	82	85
Somewhat Agree	24	12	10
Neutral	12	2	4
Somewhat Disagree	2	3	2
Strongly Disagree	0	1	0

The data indicates that the respondents seem to understand that there is a relationship between emissions, maintenance/repair, and fuel economy.

The case study sample was asked how much they were willing to pay to repair their car so that it would fall into the good category. Fifteen of the 20 (75%) case studies said they would pay \$100 dollars or more. One person said he would pay \$250 to make sure his car is low polluting. Two others said they would pay whatever it would take to improve the performance and efficiency of the vehicle. One person claimed she had spent \$575 dollars as a result of the sign, in order to make it flash a good reading. The \$575 dollars was spent on an air flow valve, two tune-ups and a diagnostic test. This suggests that the majority of the case study sample understands the link between a well-maintained vehicle, air pollution and fuel economy.

3. INTENTIONS

Intentions to respond to the RSIS were measured by asking the respondents if they planned to do anything in response to the RSIS system. Eight percent plan to do something in response to the RSIS. More men than women plan to do something.

The analysis of the data by stratum found that 31% of those in the poor stratum and 16% of those in the fair stratum planned to do something to their cars in response to the sign. (Table 13).

Table 13 - Percent Who Plan to do Something Within Stratum (Percentages)

Response	Poor	Fair	Good
Yes	31	16	6
No	69	84	94

The analysis of the data by stratum found that most of those in the poor stratum plan to have their car maintained while most in the fair stratum plan to have their car checked. (Table 14).

Table 14 - What is Planned Within Stratum (Percentages)

Planned to Do	Poor	Fair	Good
Maintenance	18	10	5
Car Checked	13	7	2
Other	7	0	0
Don't Know	0	1	0

The case study sample discussed the influence of the RSIS on their intentions to fix their cars. One of the motorists who had a poor reading intended to get a tune-up soon after the interview and wanted to check the results by driving past the sign. He said, "I'm going to take my car in to get tuned in the next week or so and we'll see if it changes." Three others thought that the sign might encourage people to do "something." One comment made by a motorist with a poor reading was, "Well, if I was driving a new car and it came up poor, I would check it out immediately because it shouldn't." Other responses by a motorists with poor readings were, "I think it's going to be the same motivation as it is with most people, is it time for my emissions sticker? I've got a heads up now that something's not right, at least I can go in and get the emissions sticker or have work on it before I get turned down and have to go back again. At least it's a heads up, when you get turned down for a sticker and you say I had no idea, it's not true." Five of the six motorists in the good stratum thought that the sign would encourage people to get their cars checked and said they would take action if the sign reported an unsatisfactory reading on their car. One motorist with a good reading said, "Yea, I mean I know I would if I saw my car was in poor health I would want to do something about it, you'd want to figure out what the problem is." Most of the motorists interviewed in the case studies believed the sign would encourage action to reduce air pollution.

4. ACTION

Actual responses to the sign were measured by asking the respondents if they had already done something to their cars in response to the RSIS, less than 2% of the weighted population said they had done something.

The analysis of the data by stratum found that there were more in the poor stratum(the target population) who responded to the sign (16%). (Table 15).

Table 15 - Responses to the RSIS by Stratum (Percentages)

Response	Poor	Fair	Good
Yes	16	2	1
No	84	98	99

More men than women actually did something in response to the RSIS (more women than men had good readings). Six percent had their car maintained while 3% had their car checked. The most common problem that was found was the need for a tune up. All of the cars with a problem reported having had it fixed.

The respondents who had their car maintained or checked were asked if any part of the RSIS (sign, brochure, hotline) influenced their decision. The poor stratum was influenced the most by the sign. (Table 16). The influences on those who had done something by stratum, other than the RSIS, were knowing that their car was running poorly or knowing that their car was in need of a check up.

Table 16 - Influence of the RSIS on Action Within Stratum (Percentages)

Influence	Poor	Fair	Good
Sign	12	1	1
Brochure	3	0	0
Hotline	0	0	0
Other	2	1	1

Three of the people interviewed in the case studies had repaired their vehicles as a result of the sign. One of the motorists with both a good and fair reading responded to the question of having done anything as a result of the sign, "I got it fixed, it needed an air flow valve for \$400 dollars." Another motorist with both a good and fair reading claimed the, "first time I went by it I got a good reading and eventually I got a fair rating so I gave my truck a tune-up." A motorist

who had received both a good and poor reading said, “I worked-on my car (tune-up), but I’m conscious of it because I drive an “82 Wagoneer.”

AUXILIARY SYSTEMS

The research design also included the use of auxiliary information systems. This included brochures, an information hotline, and media coverage. Brochures were sent to 955 people who had driven past the sign representing those in the poor, fair and good categories. However, only 15% (73) of the sampled population (actual telephone survey) said they had received one. Of those 73, 60% glanced at the brochure while 40% read it all. Of those who looked at the brochure, most (87%) found it very or somewhat helpful. No one from the case studies had received a brochure in the mail. They were given a brochure during the interview and asked for their feedback. For the most part they were positive. The most consistent comment was that they found it interesting but would have liked more technical information.

Very few people from the telephone survey population called the hotline (4). One (poor) found it somewhat helpful, one (good) was neutral, one (fair) thought it was not helpful, and one (fair) did not know. No one from the case studies had called the hotline. The monitoring system for the hotline recorded 77 calls. Of those 77, 69 were mailed brochures, sent a motor vehicle emissions fact sheet from the Colorado Department of Public Health and Environment, called back or sent a short letter. A high rate of “hang ups”, well over half of the total calls, was reported. Ninety-five percent of these hang ups were on option 2, the option focused on those receiving poor or fair readings (42% called in on option 2). We suspect that the low number of calls to the hotline is due to the fact that few motorists reported seeing the phone number.

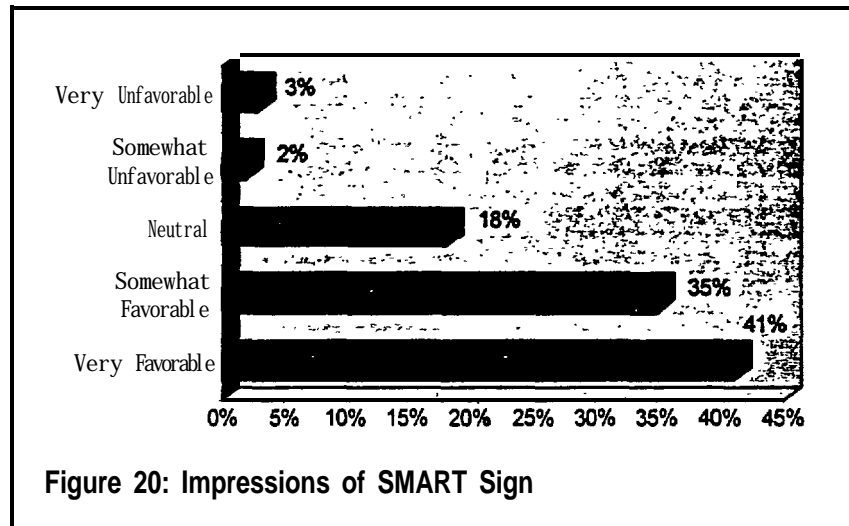
The influence of the media was assessed indirectly by asking those in the telephone survey who had heard of the sign before driving past it where they had heard of it. Seventy-six percent of those who had heard of the sign (155) before driving past had heard of it from the media. The others who had heard of the sign, had heard from 12% of others who had driven past (18) and 5% had heard of the sign from the brochures (8).

The auxiliary systems, the brochure and hotline were not as effective as the sign in raising public awareness of the importance of a well-maintained car. This is due in part to an ineffective delivery system. Most of the respondents had not seen the brochure and only a few had used the hotline. The media, however seem to be reaching more people. Three-fourths of those who had heard of the sign before driving past had heard of it from the media.

DISCUSSION

Impressions of the SMART Sign:

Impressions of the sign were favorable. Seventy-six percent of all of the weighted population had favorable impressions of the sign and only 5% had an unfavorable impression. (Figure 20)



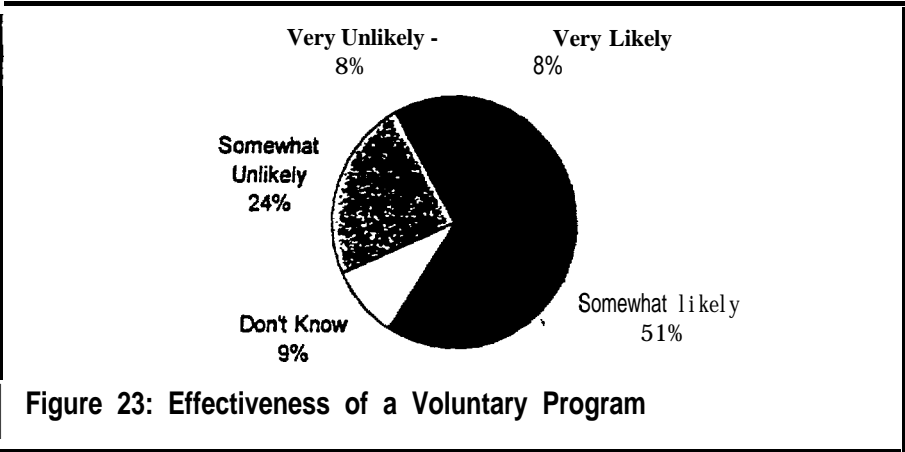
The analysis of the data by stratum found that approximately two-thirds of all the strata were favorable (split evenly between very favorable and favorable) toward the sign. Those in the good stratum were slightly more favorable than those in the fair stratum. Men were more favorable than women to the sign. Very few were unfavorable. (Table 17)

Table 17 - Impressions of the Sign Within Stratum (Percentages)

Impressions	Poor	Fair	Good
Very Favorable	37	36	42
Somewhat Favorable	32	33	35
Neutral	21	25	17
Somewhat Unfavorable	7	4	2
Very Unfavorable	3	2	4

Voluntary Program Effectiveness:

The motorists were also asked if they thought that a voluntary program such as the RSIS program would result in people getting their cars in better operating condition. Fifty-nine percent thought it was likely and 32% thought it was unlikely. (Figure 23)



Analysis of the data by stratum found that almost 2/3 of all the strata felt that the RSIS program would result in cars actually getting fixed. Approximately 1/3 felt it was unlikely to result in cars actually getting fixed (especially in the fair stratum) and 1/3 did not know. (Table 20)

Table 20 - Effectiveness of a Voluntary Program Within Stratum (Percentages)

Responses	Poor	Fair	Good
Very Likely	9	6	8
Somewhat Likely	50	45	51
Don't Know	15	15	9
Somewhat Unlikely	21	21	24
Very Unlikely	6	14	8

Seventy percent of the case studies (14) felt that the Smart Sign could stimulate action among the driving public. Over half of those in the poor category found the sign interesting and were in favor of it. Two of these thought that it might be a good replacement for the central emissions test while one thought it might serve as an appropriate prelude to the emissions test. Others thought that the sign might encourage some people to fix their cars. Of those with good emissions readings, most said they would fix their car if they received a reading other than good. They also felt that the sign would encourage some people to take action. One person thought that there should be more signs to make people aware of their car's condition and remarked how simple the device is in comparison to going to the "emissions testing place". Another person was disappointed to hear that the sign would be taken down. All of the people who received both a good and fair reading made favorable comments regarding the sign. Both of the people who had both a good and poor reading believed that the sign would create action. The interviewee who had received all three readings was skeptical of the technology and did not do anything as a result of the sign. He thought it might be effective for some people. In general, the sign was found to be very favorable by both the telephone sample and the case study sample.

Accomplishment of Objectives:

Component I addressed the questions:

1. Did the RSIS work (the combination of the RSD and the VMS technology)?
The data recorded by the data logger from the OTC analyzer showed no indications that the combination of the RSIS technology did not work other than under conditions such as rain or snow, accidents, equipment failure or unforeseen events.
2. Were the motorists' emission being accurately measured and reported? The data from the OTC analyzer suggests no malfunctions in the sign's ability to report the correct category of vehicle CO emissions: GOOD, FAIR, or POOR. Fluctuations of plus or minus 3% should be expected.
3. Was the correct information displayed to the appropriate motorist? The RSIS was capable of displaying the appropriate readings to the appropriate motorist. Only 1% of the respondents from a sample of 474 felt they weren't getting the right information. The software is written in such a way that a vehicle close behind you invalidates your signal which is not displayed, instead displaying for the rear vehicle. When trucks and trailers lead a pack of vehicles, it is possible for the sign time to become confused. The confusion is reset with the next 8 second gap. We estimate that this causes incorrect readings for less than 0.7% of the vehicles.

Component II addressed the questions:

1. "Did the sign influence awareness of emissions levels?" The data indicates that the sample stratum with good emissions readings has a greater awareness of their emissions

levels as indicated by the high percentage of recall of the last reading reported by the sign. In general, the motorists in the good stratum had driven past the past sign more times and recalled their readings better than those in either the poor or fair stratum. We did not reach our target population, the poor stratum, as well as we would have liked. However, approximately 2/3 of the weighted population thought the sign was informative.

2. "Did the sign influence knowledge of the relationship between emissions, maintenance/repair and fuel economy?" The data indicated that most of the motorists understand this relationship. Ninety-nine percent of the motorists believe that maintenance is important and most maintain their cars at regular intervals. Ninety-five percent thought that a well maintained cars saves money.

3. "Did the sign influence intentions to respond to the emission information in ways such as repairing the vehicle?" The data indicates that 8% of the motorists plan to do something in response to the sign.. More in the poor stratum (31%) plan to do something as compared with the other strata. The poor stratum was almost twice as likely to respond to the system as those in the fair stratum (16%) and five times as likely as those in the good stratum (6%). Most plan to have their car maintained or at least checked. This is a good indication the . stratum most in need of information from the sign is the one most likely to respond.

4. "Did the sign influence the motorists to actually do anything (action) in response to the sign?" The data indicate that the RSIS has had some influence on the motorists to actually fix or repair their car. Approximately two percent of the weighted population (1.6% of the over all fleet) report having already taken some action. This is a good indication that the system is having some influence on the motorists to actually do something to their car. Since the sign has delivered three million readings to about 232,000 unique vehicles, to the extent that the 1.6% can be extrapolated to the whole measured population, more than 4,400 voluntary repairs can be predicted.

CHAPTER III

OBSERVATIONS AND RECOMMENDATIONS

The respondents from both the telephone survey and the case studies responded favorably to the SMART sign and saw it as a potential help in solving the air pollution problem in Denver. The sign has been in operation long enough for the survey to identify drivers who claim to have made repairs. The LPR system only monitors approximately 1% of the fleet each month which is insufficient to capture on-road emissions reductions from the repaired fleet. Motorists with poor emissions (the target population) were most likely to respond to the sign. Case study participants were particularly interested in using the RSIS as a means of checking future repairs on their cars. They were disappointed that the sign's operation might be discontinued.

The sign will be continued for an additional six months. We recommend conducting focus groups for respondents from the poor stratum to enhance the responses from this target population. We also recommend administering a short version of the evaluation questionnaire towards the end of the six months as a follow up to estimate the number of actual and planned responses to the RSIS in terms of fixing cars that fall into the poor and fair strata. This new figure will be compared with the current figure. If the increase in positive responses (actual or planned repairs) is significant, we recommend finding a way to permanently fund the sign. The indications are that people will use the sign to periodically check the condition of their car and voluntarily have it "fixed". Cost-Benefit analysis was not part of this project which was a prototype design operational test project. We would recommend this as a next step.

The actual design of the sign seems to be working well. Most of the sample was able to accurately define the meaning of POOR, FAIR and GOOD. Data from the telephone questionnaire indicated an understanding of the association between car emissions, maintenance, and fuel economy. We did not see an actual increase in awareness as a result of the message "saving you money" or "costing you money", but the awareness was already high. The case study sample reacted positively to this message. We recommend keeping the message as a learning tool.

At this point in time the auxiliary systems have not been effective. The brochure was accessed by very few participants in the telephone survey and none of the participants in the case studies. The case study participants were handed a brochure and asked for their comments. As a result of these comments, we recommend writing a pamphlet or brochure that gives more technical information. The pamphlet should also explain the actual logistics of the sign such as not driving too close to the car in front of you. New avenues for distribution should be explored.

The hotline should be continued as an avenue for information, although the recall of the number was low, No one recalled the actual phone number. Repositioning the hotline sign to a more visible location should improve recall. There were many hang-ups on the hotline, especially on option 2 which was directed to the poor and fair strata Perhaps an introduction that would catch their attention and encourage them to continue listening rather than hanging up should be explored.

Overall the RSIS has the potential to be an effective tool to encourage people to voluntarily fix their cars in order to improve air quality in Denver. The RSIS supports the ITS project goal to promote the use of intelligent transportation technologies *to* improve air quality. The overall response to the system was positive. Very few people felt that the system was silly or was a distraction. Most thought that it was informative and many thought it would motivate people to repair their broken vehicles. The RSIS meets the ITS project objectives of merging available technology and encouraging the public to voluntarily have their vehicles repaired. The public, as represented by the sample*, seems to understand the relationship between maintenance, emissions, and fuel efficiency. They seem to feel the SMART sign would be a useful and accepted approach to reducing harmful emissions. The case study sample would like to see the use of the SMART sign continued and to see it in other locations.

With the changes suggested above, the RSIS could be an important addition to the Central Emissions Testing Program that is already in place and it would allow Denver to have a unique opportunity to demonstrate the importance of a voluntary component to the Clean Air Program. Several presentations have been made of this project at professional organizations and national and international air quality conferences. The audiences have been very receptive and often request information on how to start a similar program in their area.

* The sampled population was recalculated (weighted) to normalize from the sampled fleet (43% good, 43% fair, and 14% poor) to the total overall fleet (86% good, 10% fair, and 4% poor, i.e. weighted sample). The total number of unique vehicles sampled from the 3,000,000 measurements was obtained from the survey results. The 474 telephone survey participants reported that they were responsible for about 5,300 readings. From these data we predict that there have been $3,000,000 \times \frac{474}{5300} = 264,717$ unique vehicles passing the RSIS.

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APPENDICES

APPENDIX A-QUESTIONNAIRE

ID #: (1-4)	NAME: _____	TELE. #: _____
	ADDRESS: _____	
	CITY: _____	STATE: _____ ZIP: _____
INT. BY: _____	DATE: _____	VAL. BY: _____ EDIT BY: _____
SAMPLE: SCORED "POOR". . . 5-1 SCORED "FAIR". . . .-2 SCORED "GOOD". . . .-3	SAMPLE: BROCHURE SENT. 6-1 NOT SENT-2 Q.24: GOT BROCHURE . . 7-1 NO BROCHURE. . . .-2	SEX: MEN. 8-1 WOMEN.-2

Hi, my name is _____. I'm with Colorado State University and we are conducting a study of driving patterns in the Denver metro area. The results of this study will help improve driving conditions for commuters and others driving in Denver. It will take only a few minutes of your time. Can you help us?

- A. Do you drive a (describe car and license #)? (SKIP TO Q.C)--- Yes. . . . 9-1
(ASK Q.B)----- No -2
- B. Could I speak to the person who drives the (describe car and license #)? (ON CONTACT, RE-ASK Q.A)--- Yes. . . . 10-1
(IF NOT AVAILABLE, GET A GOOD DATE AND TIME TO CONTACT THEM) (TERMINATE)--- No, Refused. . . -2
No such car. . . -3
Person not here. at this address.-4
RE-CONTACT: DAY/DATE: _____ TIME: _____ AM/PM
- C. (IF "YES" IN Q.A. ASK...) Have you recently driven on the exit ramp from I-25 to Speer Boulevard? (SKIP TO Q.E)--- Yes. . . . 11-1
(ASK Q.D)----- No -2
- D. (IF "NO" IN Q.C -- NOT DRIVEN THERE, ASK...) Could I speak to anyone who may have driven the (describe car and license #) in the area of I-25 and Speer Boulevard at any time during the past few days? (ON CONTACT, RE-ASK Q.A)--- Yes. . . . 12-1
(TERMINATE)--- No, Refused. . . -2
Person not here at this address. -3
Don't know who . -4
(WHEN SPEAKING WITH DRIVER, PROCEED)
- E. Do you remember seeing a special sign at the I-25 and Speer Boulevard exit that had a picture of a car and rated the "health" of passing cars? (CONTINUE WITH Q.E-1)---Yes 13-1
(TERMINATE)-----No. . . . -2
- E-1. Had you heard about the sign before seeing it? (ASK Q.E-2)-----Yes 14-1
(SKIP TO Q.1)-----No. . . . -2

E-2. (IF "YES", HEARD ABOUT BEFORE IN Q.E-1, ASK...) Where did you hear about it? (DO NOT READ OUT. RECORD ALL MENTIONED)

BROCHURES/HANDOUTS.15-1
THE NEWS MEDIA.16-1
PEOPLE WHO HAVE DRIVEN BY THE SIGN. . . 17-1
FROM HOTLINE.18-1

Now I'd like to ask you some questions about the (describe car as above in Q.1).

1. Have you had your car checked or maintained in the past year? (ASK Q.21)----- Yes.20-1
(SKIP TO Q.4)--- No-2
2. (IF "YES" IN Q.1, ASK...) When was the last time you had your car checked or maintained? (RECORD BELOW)

LAST WEEK.	21/22-01	THREE MONTHS AGO.	-06
TWO WEEKS AGO.	-02	FOUR MONTHS AGO	-07
THREE WEEKS AGO.	-03	FIVE MONTHS AGO	-08
ONE MONTH AGO.	-04	SIX MONTHS AGO.	-09
TWO MONTHS AGO	-05	SIX - TWELVE MONTHS AGO	-10
		DON'T KNOW/DON'T REMEMBER	-11

3. Why did you have your car checked or taken in for maintenance?
(PLEASE WITH...) What other reasons? (DO NOT READ OUT, RECORD ALL MENTIONS)

SAW SIGN INFORMATION (eg. SMART SIGN/sailer face car/sign at I-25 & Speer).23-1
SAW SIGN BYCHURE (eg. SMART SIGN/a quick way To Measure Car's Health)
CALLED/GOOT HOTLINE INFORMATION.24-1
REGULARLY SCHEDULED MAINTENANCE25-1
CAR WASN'T RUNNING RIGHT.26-1
PREP. FOR STATE EMISSIONS TEST (ENVIROTEST)27-1
ENVIRONMENTAL/AIR POLLUTION REASON.28-1
OTHER (LIST):

29-

(DON'T REMEMBER) . . ()

(ASK EVERYONE)

4. Over the years, there has been a lot of talk about air pollution in Denver. Do you believe that air pollution in the Denver area is... Not a problem?30-1
Not a very serious problem?..-2
A somewhat serious problem?..-3
Or A very serious problem?..-4
(UNDECIDED).-5

5. In your opinion, what are the most important causes of the air pollution problems in the Denver metro area? (DO NOT READ OUT, RECORD ALL MENTIONED)

AUTOMOBILES.	31-1	DIESELS (Cars/Buses/Trucks).	37-1
WOODBURNING.	32-1	SANDING OF STREETS	38-1
UTILITIES (Gas/Electric Co's).	33-1	INDUSTRY	39-1
COMPUTING.	34-1	TOO MUCH DRIVING	40-1
GROWTH AND SPRAWL.	35-1	GEOGRAPHY, METEOROLOGY (altitude/weather)	41-1
POOR PUBLIC TRANSPORTATION	36-1	OTHER (LIST):	

42-

(DON'T KNOW). . . ()

6. Do you believe that air pollution in Denver has gotten better, worse or stayed about the same over the last five years? (GO TO Q.7)-----Better.43-1
(SKIP TO Q.8)-----Worse-2
(SKIP TO Q.9)-----Same.-3
(SKIP TO Q.9)------(DON'T KNOW). . . -4

7. (IF "BETTER" IN Q.6, ASK...) Why do you think it has gotten better?
(DO NOT READ OUT, RECORD ALL MENTIONED)

CENTRAL EMISSIONS TESTING (Envirotest, central)	44-1	LESS WOODBURNING	47-1
BETTER CARS, LESS POLLUTING CARS	45-1	PEOPLE DRIVING LESS.	48-1
USE OF ALTERNATIVE FUEL.	46-1	PEOPLE TAKING BETTER CARE OF CARS.	49-1
		INCREASED AWARENESS OF POLLUTION	50-1
		OTHER (LIST):	

(NOW SKIP TO Q.9)

51-

(DON'T KNOW). . . ()

8. (IF "WORSE" IN Q.6, ASK...) Why do you think it has gotten worse?
(DO NOT READ OUT, RECORD ALL MENTIONED)

MORE CARS.	52-1	POPULATION GROWTH.	54-1
CENTRAL EMISSIONS TESTING (Envirotest, central)	53-1	MORE INDUSTRY.	55-1
		OTHER (LIST):	

56-

(DON'T KNOW). . . ()

(ASK EVERYONE)

15. On your (most recent) trip past the sign on Speer Boulevard, what was your car's "health" reading...
(READ OUT AND RECORD)
- | | |
|--------------------------|------|
| Good? | 85-1 |
| Fair? | 86-1 |
| Or Poor? | 87-1 |
| (DON'T RECALL) | 88-1 |

16. What does the message "Good" mean to you on this sign?
(DO NOT READ OUT. RECORD ALL MENTIONED)

CAR IS RUNNING WELL. IT'S WELL MAINTAINED	86-1	CAR IS GETTING AS GOOD GAS MILEAGE AS IT CAN	88-1
I'M SAVING MONEY.	87-1	CAR IS NOT POLLUTING	89-1
OTHER: (LIST)		OTHER: (LIST)	
			90-
		(DON'T KNOW)	91-1

17. What does the message "Fair" mean? (DO NOT READ OUT. RECORD ALL MENTIONED)

CAR IS OK, BUT I NEED TO WATCH IT.	92-1	CAR IS ON THE VERGE OF BECOMING A HIGH POLLUTER AND NEEDING MAINTENANCE.	95-1
CAR IS POLLUTING MORE THAN IT SHOULD	93-1	OTHER: (LIST)	
CAR IS NOT GETTING AS GOOD GAS MILEAGE AS IT SHOULD.	94-1		96-
		(DON'T KNOW)	97-1

18. What does the message "Poor" mean? (DO NOT READ OUT. RECORD ALL MENTIONED)

CAR NEEDS MAINTENANCE	98-1	I'M LOSING MONEY	101-1
CAR IS A HIGH POLLUTER.	99-1	OTHER: (LIST)	
GETTING POOR GAS MILEAGE.	100-1		102-
		(DON'T KNOW)	103-1

19. Is your general impression of the sign...
(READ OUT AND RECORD)

(ASK Q.20)--: Very favorable?	104-1
: Somewhat favorable?	105-1
(SKIP TO Q.22)----- Neither favorable nor unfavorable?	106-1
(SKIP TO Q.21)--: Somewhat unfavorable?	107-1
: Or Very Unfavorable?	108-1

20. (IF "VERY" OR "SOMEWHAT FAVORABLE" IN Q.19, ASK...)

Why do you feel your impression was favorable? (DO NOT READ OUT. RECORD ALL MENTIONED)

ATTRACTIVE.	109-1	ATTENTION GETTING.	110-1
CUTE/PLAYFUL.	111-1	MOTIVATES PEOPLE TO REPAIR BROKEN CARS	112-1
INFORMATIVE	113-1	OTHER: (LIST)	
			114-
		(DON'T KNOW)	115-1

(SKIP TO Q.22)

21. (IF "VERY" OR "SOMEWHAT UNFAVORABLE" IN Q.19, ASK...)

Why do you feel your impression was unfavorable?

(DO NOT READ OUT. RECORD ALL MENTIONED)

DISTRACTION	116-1	INFORMATION IS WRONG	117-1
SILLY LOOKING	118-1	DIDN'T HAVE TIME TO READ IT.	119-1
NOT ENOUGH INFORMATION.	120-1	DON'T BELIEVE THE INFORMATION IS FOR MY CAR.	121-1
INVASION OF PRIVACY/RESSENT IT	122-1	OTHER: (LIST)	
			123-
		(DON'T KNOW)	124-1

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- (ASK EVERYONE)
22. Do you recall seeing a second sign, just beyond the one with the car? (CONTINUE WITH Q.23)-----Yes . . . 121-1
(SKIP TO Q.24)-----No . . . -2
23. (IF "YES", SAW SECOND SIGN IN Q.22, ASK...) Do you recall seeing a phone number on that sign? (ASK Q.23a)-----Yes . . . 122-1
(SKIP TO Q.24)-----No . . . -2
- 23a. (IF RECALL PHONE NUMBER IN Q.23, ASK...) What was it? (ENTER NUMBER AT RIGHT) # ON SIGN
WAS: () -----
100-100 100-100 100-100

- (ASK EVERYONE)
- I would like to ask you a few questions about some other sources of information on your car's health.
24. Did you get a brochure called "Smart Sign: A Quick Way to Measure Your Car's Health"? (ASK Q.25)-----Yes . . . 133-1
(SKIP TO Q.27)-----No . . . -2
25. (IF "YES", GOT THE BROCHURE IN Q.24) How did you get the brochure? (DO NOT READ LIST, RECORD ALL MENTIONED)
- | | | | |
|------------------------------|-------|------------------------------|-------|
| CAME IN THE MAIL | 134-1 | FROM A FRIEND/RELATIVE . . . | 137-1 |
| AT CONOCO STATION | 135-1 | OTHER (LIST): | 138- |
| CALLED THE HOTLINE | 136-1 | DON'T REMEMBER | 139-1 |
26. Would you say you... (READ OUT AND RECORD) Just looked it over briefly? 145-1
Read some parts of it? . . . -2
Or Read all of it? . . . -3

26a. What information did you find most useful?
(DO NOT READ LIST, RECORD ALL MENTIONED)

PHONE NUMBER FOR MORE INFORMATION	146-1	QUESTION & ANSWER SECTION . . .	149-1
MAP/DIRECTIONS TO SIGN	147-1	OTHER (LIST):	150-
EXPLANATION OF THE SIGN	148-1	(DON'T REMEMBER/NOTHING) . . . ()	

26b. Was the brochure and it's message...
(READ OUT AND RECORD)

Very helpful?	151-1
Somewhat helpful?	-2
Neutral?	-3
Not Very Helpful?	-4
Or Not At All Helpful?	-5
(DON'T KNOW)	-6

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(ASK EVERYONE)

27. Did you try to call a special Hotline telephone number, which is listed both on the sign and in the brochure?

(ASK Q.27a)-----Yes.140-1

(SKIP TO Q.32)-----No-2

- 27a. How did you get the information to call the Hotline number?

(DO NOT READ LIST. RECORD ALL MENTIONED)

GOT NUMBER FROM SIGN.141-1

GOT NUMBER FROM BROCHURE.142-1

FROM A FRIEND/RELATIVE.143-1

OTHER (LIST):

144-
(DON'T KNOW). ()

28. Did you get through when you called?

(SKIP TO Q.29)-----Yes.152-1

(ASK Q.28a)-----No-2

- 28a. (IF "NO", DID NOT GET THROUGH IN Q.28, ASK...)
Why didn't you get through?

153/154-

(NOW SKIP TO Q.31)

(IF "YES", GOT THROUGH IN Q.28, ASK...)

29. Did you receive some materials or information from the Hotline call?

(SKIP TO Q.30)-----Yes.155-1

(ASK Q.29a)-----No-2

- 29a. (IF NO, DID NOT RECEIVE MATERIALS IN Q.29, ASK...)
Why not?

156/157-

(NOW SKIP TO Q.31)

30. (IF "YES", RECEIVED MATERIALS IN Q.29, ASK...)

What did you receive from the Hotline call? (DO NOT READ OUT. RECORD ALL MENTIONED)

THE BROCHURE "SMART SIGN" IN THE MAIL.158-1

TOLD TO GET THE BROCHURE "SMART SIGN" AT CONOCO.159-1

LIST OF REASONS FOR "FAIR" OR "POOR" RATING . . .160-1

FAX/TELEPHONE NUMBER FOR TECHNICAL QUESTIONS . .161-1

OTHER (LIST):

162-
DON'T REMEMBER163-1

31. Would you say the Hotline was...

(READ OUT AND RECORD)

Very helpful.164-1

Somewhat helpful.-2

Neutral-3

Not very helpful.-4

Or Not At All Helpful?-5

(DON'T KNOW).-6

(ASK EVERYONE)
32. Have you done anything about your car as a result of either seeing your car's "health" reading on the sign, seeing the brochure or calling the Hotline number?

(CONTINUE WITH Q.33)---Yes . . .165-1
(SKIP TO Q.35)-----No. . . .-2

(IF "YES", DONE SOMETHING IN Q.32, ASK...)
33. Did you get your car checked?

(ASK Q.33a-a)-----Yes . . .166-1
(SKIP TO Q.34)-----No. . . .-2

33a. (IF YES, CAR CHECKED IN Q.33, ASK...)
Which, if any, of the following sources of information had an influence on your decision to have your car checked? (READ EACH AND RECORD BELOW)

---INFLUENCED---	
YES	NO
1) Seeing the Smart Sign? . . .167-1	-2
2) Reading the brochure? . . .168-1	-2
3) Calling the Hotline? . . .169-1	-2
4) Some other reason? . . .170-1	-2
(LIST):	
	171-

33b. When you had your car checked, was a problem found? (ASK Q.33c)-----Yes, problem found 172-1
(SKIP TO Q.34)---No, no problem found -2
(DON'T KNOW)-3

33c. (IF "YES", PROBLEM FOUND IN Q.33b, ASK...)
What was the problem? (DO NOT READ OUT. RECORD ALL MENTIONS)

EMISSIONS CONTROL SYSTEM. . . .173-1	OIL/LUBRICATION176-1
ENGINE TUNING174-1	OTHER (LIST):
IDLE/ACCELERATOR.175-1	177-
	(DON'T REMEMBER).()

33d. Were you able to get the problem fixed? (SKIP TO Q.34)-----Yes . . .178-1
(ASK Q.33e)-----No. . . .-2

33e. (IF "NO", DIDN'T GET IT FIXED IN Q.33d, ASK...)
Why couldn't you get the problem fixed? (PROBE AND CLARIFY RESPONSES)

179/180-
181/182-

34. Aside from having the car checked or maintained, have you done anything else as a result of the information from the sign, brochure or Hotline? (ASK Q.34a-b)-----Yes . . .183-1
(SKIP TO Q.35)-----No. . . .-2

34a. (IF YES, DID SOMETHING ELSE IN Q.34, ASK...)
What else have you done? (DO NOT READ OUT. RECORD ALL MENTIONS)

SOLD/TRADED CARS.184-1	OTHER (LIST):
LIMITED DRIVING/USE OF CAR. . . .185-1	186-
	DON'T REMEMBER.()

34b. Which, if any, of the following sources of information had an influence on your decision to do this? (READ EACH AND RECORD BELOW)

---INFLUENCED---	
YES	NO
1) Seeing the Smart Sign? . . .187-1	-2
2) Reading the brochure? . . .188-1	-2
3) Calling the Hotline? . . .189-1	-2
4) Some other reason? . . .190-1	-2
(LIST):	
	191-

(ASK EVERYONE)

35. As a result of the information you received from the sign, the brochure or the Hotline, do you plan to do anything (else) in the future regarding your car? (ASK Q.36)-----Yes . . . 192-1
(SKIP TO Q.37)-----No-2

36. (IF "YES", PLAN TO DO SOMETHING IN Q.35 ASK...) What do you plan to do? (DO NOT READ OUT. RECORD ALL MENTIONED)

CALL THE HOTLINE. 193-1
GET A BROCHURE. 194-1
GET MY CAR CHECKED. 195-1
DO SOME TYPE OF MAINTENANCE 196-1
OTHER: (LIST) _____ 197-
(DON'T KNOW). 198-1

(ASK EVERYONE)

Now I would like to get your general opinions on car maintenance.

37. Do you agree or disagree that keeping a car well-maintained can reduce air pollution? (IF "AGREE" OR "DISAGREE", ASK...) Would you say you "strongly" (agree/disagree) or "somewhat" (agree/disagree)? (RECORD)
- Strongly Agree. 199-1
Somewhat Agree.-2
Neither Agree nor Disagree -3
Somewhat Disagree-4
Strongly Disagree-5

38. Do you agree or disagree that keeping your car well-maintained actually saves money? (IF "AGREE" OR "DISAGREE", ASK...) Would you say you "strongly" (agree/disagree) or "somewhat" (agree/disagree)? (RECORD)
- Strongly Agree. 200-1
Somewhat Agree.-2
Neither Agree nor Disagree -3
Somewhat Disagree-4
Strongly Disagree-5

39. How often does this car get maintained? (DO NOT READ OUT UNLESS RESPONDENT HESITATES)
- Monthly? 201-1
Every three months?-2
Every six months?-3
Yearly?-4
Rarely?-5
Or Never?-6
(DON'T KNOW).-7

40. Why is this car maintained? (DO NOT READ OUT. RECORD ALL MENTIONED)

FOR SAFETY. 202-1 TO LOWER AIR POLLUTION 204-1
FOR RELIABILITY 203-1 FOR FUEL ECONOMY 205-1
OTHER: (LIST) _____ 206-
(DON'T KNOW) 207-1

41. Generally, what is done to maintain this car? (DO NOT READ OUT. RECORD ALL MENTIONED)

OIL CHANGE. 208-1 BATTERY WORK OR REPLACEMENT. 210-1
TUNE-UP 209-1 TIRES. 211-1
OTHER: (LIST) _____ 212-
(DON'T KNOW) 213-1

42. How likely do you think it is that the voluntary program that gives people information about their car's performance -- like the SMART SIGN program -- will result in people getting their cars in better operating condition? Would you say... Or Very unlikely?-5
- Very likely? 214-1
Somewhat likely?-2
Don't know?-3
Somewhat unlikely?-4
- (READ OUT AND RECORD)

Now I'd like to ask a few questions about you and your household

43. How many miles do you, personally, drive per week?
Would you say...
(READ OUT ONLY IF RESPONDENT HESITATES)
- Up to 80 miles? 215-1
80 to 150 miles? -2
151 to 250 miles? -3
More than 250 miles? -4
(DON'T KNOW) -5
44. How many vehicles -- in total --
does your household have?
(DO NOT READ OUT)
- ONE 216-1
TWO -2
THREE - FOUR -3
FIVE - SEVEN -4
EIGHT OR MORE -5
REFUSED/NO ANSWER -6
45. What is your current marital status?
(DO NOT READ LIST)
- Married 217-1
Single -2
Separated -3
Divorced -4
Widowed -5
(REFUSED) -6
46. Including yourself, how many people
are in your household?
(DO NOT READ LIST)
- One 218-1
Two -2
Three -3
Four -4
Five or more -5
(REFUSED) -6
47. In what county do you live?
- Denver 219-1
Adams -2
Arapahoe -3
Boulder -4
Douglas -5
Jefferson -6
48. How old were you on your last birthday?
Would that be... (READ OUT AND RECORD)
- 16 to 24 220-1
25 to 34 -2
35 to 44 -3
45 to 54 -4
55 to 64 -5
Or 65 and older? -6
(REFUSED) -7
49. What was your last year of school?
(DO NOT READ UNLESS RESPONDENT HESITATES)
- Grade school (last grade attended) 221-1
High School Graduate -2
Vocational/trade school -3
Some College -4
College graduate -5
Graduate school -6
(REFUSED) -7
50. And what is your race or ethnic heritage?
(DO NOT READ UNLESS RESPONDENT HESITATES)
- Asian 222-1
White/Anglo/Caucasian -2
Black/Negro/African American -3
Chicano/Latino/Hispanic -4
American Indian/Native American -5
Other:(SPECIFY) _____
(REFUSED) -9
51. What is your approximate annual household
income before taxes? (s it...
(READ OUT AND RECORD)
- Less than \$10,000? 223-1
\$10,000 to 19,999? -2
\$20,000 to 35,999? -3
\$36,000 to 49,999? -4
\$50,000 to 69,999? -5
Or \$70,000 and over? -6
(REFUSED) -7

Thank you very much for your help!!!

APPENDIX B - CASE STUDY PROTOCOL & REPORTS

Case study Questions

Section 1: Introduction

Upon meeting the interviewee I introduce myself by saying,

“Hi, my name is David Williams. I am a graduate student at Colorado State University. I am going to ask you some questions, in addition to the telephone questionnaire you already answered, regarding the sign at Speer Blvd. Included in my interview will be some general, as well as some environmental/economic type questions. The latter questions are ones of special interest to me in completing my master’s research. I appreciate your time and your input.”


The next three sections are a checklist of questions, not necessarily read word for word.

Section 2: IVHS Project

- What was your first impression of the sign?
- What do you remember?
(probe - smiley face
 - good, fair, poor
 - cloud
 - phone # on next sign)
- How many times have you been by the sign?
- Did you understand it at first?
- Did you notice the message at the bottom of the sign?
(probe - Saving you money?
 - Costing you money?)
- Did you notice a second sign?
- Did you call the phone number?
- What was it like seeing the sign?
(probe - easy to see
 - see your reading)
- Would you have liked an earlier sign saying what was coming up?

- Did you find it hard to see the sign? Why or why not?
- Describe your experience on the ramp?
- Why do you think the sign is there?
- How did you feel about seeing the sign?
- Do you like the sign? (Is it good, helpful? Why or why not? How can it be improved to be made better?)
- Do you think anyone is going to do anything as a result of the sign?
(probe - Why or why not?)
- Have you done anything as a result of the sign?
(probe - Why or why not?)
- Did you receive a brochure?
(If not, hand them one and let them read it)
- What do you think about the brochure?
(probe - is it informative?
- was the map helpful?)
- Would you have liked to have seen the brochure before driving past the sign?

Section 3: General Questions

- Do you agree or disagree that keeping your car well-maintained actually saves money?
(probe - Why do you agree or disagree?)
- Do you agree or disagree that keeping a car well-maintained can reduce air pollution?
(probe - Why do you agree or disagree?)
- How much would you be willing to pay to fix your car so that it falls into the good category?
(Probe for highest dollar amount)
- What is the air pollution problem? (Probe for brown cloud,  etc.)
- Do you believe that the “brown cloud” is caused by the carbon monoxide emissions from vehicles? (Probe for Nox, particulates, etc.)

- What do you suggest we do about the problem? (Probe for bus, light rail, no drive days, HOV, car pools, alternative fuels, etc.)

Depending on the answer to the last question, the interviewee will be directed to the appropriate question in the next section. The following question will assess the amount the person is willing to pay for his/her solution to air pollution. Along with the appropriate question will follow the registration scenario question.

Section 4: Scenario Questions

Bus

- If the bus was accessible (for example, if the bus stopped within 2 blocks of your home and work), would you pay \$10 dollars for a monthly bus pass? (If yes to \$10 dollars, go to \$20 dollars, if no to \$10 dollars, go to \$5 dollars). (Probe for highest dollar amount)
- If it was possible that the R'TD could be subsidized through a gas tax would you be more willing to use the system? For example, the government collected 2 cents on every dollar spent on gas, and the money was used by a private bus system. (probe - Why or why not?)

Light Rail

- If the light rail was accessible (for example, if it stopped within 2 blocks of your home and work), would you pay \$10 dollars for a monthly light rail pass? (If yes to \$10 dollars, go to \$20 dollars, if no to \$10 dollars, go to \$5 dollars). (Probe for highest dollar amount)

No Drive Days

- If it were possible next year that your vehicle would be given a red sticker (meaning that you couldn't drive on a bad air pollution day), would you pay \$10 dollars to be able to drive on that day? (if yes to \$10 dollars, go to \$20 dollars, if no to \$10 dollars, go to \$5 dollars). (Probe for highest dollar amount)

HOV

- If the HOV lane was more accessible (for example, if it was open during off-peak hours, in the afternoon and night, would you be in favor of a gas tax to permit more availability. For example, the government collected 2 cents on every dollar spent on gas. (Probe - why or why not?)

Car Pools

- If you were given five dollars-a day by your employer to car pool with at least one other person to work, would you willing to participate? This program would involve a tax credit for your employer. (Probe for highest dollar amount. If yes to five dollars stop the bidding game, if no to five dollars go to 10 dollars, if no to \$10, go to \$15, etc.) (Probe - why or why not?)

Alternative Fuels

- If it cost you \$1000 dollars to convert your car, or second car, to use compressed natural gas (CNG), propane, or electricity in order to reduce air pollution, would you? In this situation, CNG, propane, and electric stations would be as available to you as conventional gasoline is available presently, and the alternative fuel prices would be the same as present gas prices. (Probe for highest dollar amount, if yes to \$1000, go to \$1500, if yes to \$1500, go to \$2000, etc., if no to \$1000, go to \$500, if no to \$500, go to \$250, if no to \$250, go to \$100, if no to \$100, go to \$50, if no to \$50, stop). (Probe - why or why not?)

Registration

- Would you be willing to participate in a program for an emission based registration fee program?
(for example: If you were charged x amount of dollars per 100 grams of CO, based on the number of miles you drove that year, would you accept that as your registration fee? This cost would provide revenue towards mass transit. Also, you would be granted a refund of \$50 dollars if your car's emissions were under a standard level.)
- How much would you be willing to pay for an emissions test? (Probe for highest dollar amount)

The next two questions are asked of each participant regardless of which scenario they were directed to.

Government Confidence

- In general, do you have confidence in the work that the government does?
- Do you have confidence that the government can improve the air quality?
- Those are all the questions I have for you, "thank you very much for your time."

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Case study interviews

Case #1

Poor

What was your first impression of the sign?

I had heard about it on the radio and was driving up the ramp

Registered poor and was expecting something

Figured “Big Brother” was going to be watching

What do you remember?

Picture of a vehicle - caricature

Saving you money or get your car tuned up or something

The next time - drove slightly differently

first time accelerated

second time - fair

pet peeve - this whole thing, clean air thing, shouldn't suffocate - but the whole issue of env. f cl. air is blown way out of proportion - there's a level of importance, but it becomes national fetish to the point where you radical extremists where animals are more important than people, just awful kinds of things - I'm just very sensitive to it -it has literally chased industry out of the country - I have kids and they are not going to have the opportunities that I had because we don't have businesses in this country that we did when I was a kid and I don't believe we can survive as a nation of McDonald's clerks - a service industry and that's what we're coming to - we've chased away the chemical companies, the steel manufacturers because they're horrible polluters, but they also pay bills - they've simply gone someplace else (out of sight, out of mind), - we just placed the pollution

How many times have you been by the sign?

2 - At what point have we solved a problem and at what point are we trading a problem. There are a lot of people who drive older vehicles who economically can't afford to buy a \$20,000 dollar vehicle every year. If I was the auto industry, I would think that this air pollution thing is the greatest thing that ever happened - forces people who can barely pay their bills to go out and buy a brand new vehicle

Did you understand it at first?

I understood that there was something going on - another way to make sure that we clean up the air

Did you notice a second sign?

No - trying to drive the car and general advertising - try to ignore, prefer to drive safely

Would you have liked an earlier sign saying what was coming up?

Part of the question is - what are you trying to get out of this (me- public awareness) I don't think many people are not aware of the issue - there are a lot of strong opinions, but awareness is not a problem

Did you find it hard to see the sign? Why or why not?

Not really, the way it's positioned, it's right there

Describe your experience on the ramp?

Didn't know what poor meant - Was it a three point grading system, five point, what were my options? - Was there lousy, was there fair, was there good, excellent, I don't know - I have to wonder if there's a difference between a car and a light duty truck, I mean what I'm driving is a van, I have to believe that a 8 cylinder van is going to have a different output than a 4 cylinder passenger car and what does that mean, - What does it do when a diesel goes by? I understand that all of that black filth that comes out of diesel engines is good for me - I mean we don't even test those

Why do you think the sign is there?

(Air pollution public awareness vehicle)

How did you feel about seeing the sign?

(Mentioned above)

Do you like the sign? (Is it good, helpful? Why or why not? How can it be improved to be made better?)

The way it is right now it doesn't do anything - it tells me if I drive my car a particular way I get a particular reading, but what does that mean, it tells me if I'm driving an 8 cylinder vehicle it puts out more carbon monoxide than a 4 cylinder vehicle - I don't know what it's telling me - it's kind of like true-false questions, what do you really know and what is the point are you trying to shame me into tuning my car up more frequently - I tune it up twice a year as it is - it's quite well maintained - I don't put that many miles on it anyway - I don't like vehicles - I wish we had public transportation that went somewhere, but living in the West that doesn't work because of the way we designed our cities - we're spread out - if you go back east - I lived in Milwaukee for a year, you can get somewhere - out here you don't have city centers, you have to make multiple transfers to get from one point to another - we never designed our cities around public transportation therefore we can't utilize public transportation - RTD is a joke - next to the Maytag repair man, RTD drivers are the loneliest people in town - so if we really want to solve problems instead of putting a lot of money into harassing the people, instead of running Envirotest, which makes particular individuals quite wealthy - my daughter just went through this whole thing with Envirotest, she drives a 1980 Toyota pickup, she had to put 300 dollars worth of repair into her vehicle in order to pass the emissions and all it did was drop the carbon monoxide one point, and she works for \$7.50 an hour - is this forcing her to go out and buy a \$20,000 vehicle or \$25,000 vehicle - she can't do it, it's not possible and the thing is what are we trying to do with this, are we really trying to solve problems or are we trying to create problems

What is the air pollution problem?

CO because of what it does to the blood - Effort is important, but we've done that, as usual, as soon as the government solves a problem now it's got to create some new ones

Do you believe that the "brown cloud" is caused by the carbon monoxide emissions from vehicles?

No, it's invisible

What do you suggest we do about the problem?

Monitor it as a city, stay on top of carbon monoxide and we need to have programs that help people keep it maintained - better equipment on cars is also important, but not to where you can't work on your own car- make sure that we're solving problems and not creating problems - mass transit as an option - can't rely on mass transit - works odd hours - some people have regular hours

If the bus was accessible (for example, if the bus stopped within 2 blocks of your home and work), would you pay \$10 dollars for a monthly bus pass?

Bus stop in front of his house, but can't get from his house to Golden in less than forty minutes , Yes, would pay \$10 dollars for days that are predictable. \$20 - depends on how much use - compares the cost to the car - also says it would be great for his kids

If it was possible that the RTD could be subsidized through a gas tax would you be more willing to use the system? For example, the government collected 2 cents on every dollar spent on gas, and the money was used by a private bus system.

RTD is a pet peeve - never had a good RTD board - solving the problem to get people from point A to B has never been a commitment or priority - has lobbied the RTD before for better solutions for seniors - would rather see his tax money go into vouchers for seniors or handicapped rather than into huge buses that carry no people

Would you be willing to participate in a program for an emission based registration fee program? (for example: If you were charged x amount of dollars per 100 grams of CO, based on the number of miles you drove that year, would you accept that as your registration fee? This cost would provide revenue towards mass transit. Also, you would be granted a refund of \$50 dollars if your car's emissions were under a standard level.)

concept is interesting - but knows people who tunes the car to get through the test and then tune again to where it performs properly - preference is a transit system that gets you where you need to go and is self-supporting - people will pay for something that works, why should we pay for something that doesn't work - if they can convince me that it cost 25-30 cents a mile to drive a car, which is easy to do considering insurance, and a bus pass runs at about that cost or lower, I save money using mass transit

If we really want to solve the problem I suggest we work on some wisdom and understanding and we come up with systems (mass transit vs. bumper to bumper traffic) that solve the problem - the other thing is, we have one or two days that are out of line (CO exceedence) - now we're measuring particulate pollution - nobody has ever proven that particulate pollution has done anything to anybody - some studies say it might be a problem - nonsense - we're saving jobs down at the health department is what we're doing - my grandfather remembers particulate pollution from coal fired locomotives, heat - when there was nothing but buffalo there was particulate pollution because we live in a dry, semiarid environment and when something goes by, it picks up a lot of dust - particulate problem, will never solve, unless you make everybody sit still and have a good strong rain storm - we're solving problems that don't exist which actually creates problems

Did you receive a brochure?

No - also, as we!! as auto manufacturers, it's a great little industry for auto mechanics too, how much pollution do you suppose is created, energy is consumed when we manufacture a car - when you consider the creation of paint, plastic, rubber, metal - now do you think it's going to create as much pollution driving down the road during it's lifetime as it did when it was manufactured, but we're solving the problem by manuf. more cars, by getting old cars off the road, I really question if there's any logic here - it's far economical than logical, as far as I'm concerned - airplane fuel - they dump thousands of gallons of airplane fuel before they land - they have to, to make them less dangerous - where does that go? - Are we solving problems? I don't think so

What do you think about the brochure?

My car's readings went from poor to fair - my car got better - commented on brochure's message, varying day to day and parts wearing out - we took my wife's Toyota to Envirotest and it happens to be a stickshift - the gal that was operating the car while it was on the dynamometer - she didn't know how to run a stickshift - she was trying to get a!! of the rpm's in first gear - she damn near burned up my wife's car - they finally had to override because she didn't know how to drive a stickshift - the car was passed due to her inability to drive a car- what are we fixing here?- what are we solving here? - it's not a funny joke - it's a fine brochure, but it's pretty simplistic- it is interesting that it is subsidized by Conoco - everyone should be subsidizing that (Ford, GM, etc.) sell more cars, create more repair work

Would you have liked to have seen the brochure before driving past the sign?

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, abso!ute!y, that's why I tune my car up twice a year - well-maintained engine

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Yes

How much would you be willing to pay to fix your car so that it falls into the good category?

I don't think the Envirotest is relevant - I regularly spend several hundred dollars a year to get my car tuned up - tunes the car up for reliability, efficiency, less cost - I'm more ecologically aware because I'm recycling an old car

How much would you be willing to pay for an emissions test?)

Is it going to cost me hundreds of dollars for nothing? - so it's a valuable service if it's set up properly - let's work on cars that people can tune and fix themselves and then give them classes on how to do that

In general, do you have confidence in the work that the government does?

No

Do you have confidence that the government can improve the air quality?

-Through the programs that have been put in place, the air quality has been improved, but then we don't stop when the problem has been solved - we don't decide, ok, that's good enough - yes, the government can and should help us clean up pollution - no it's not going about it correctly

Case #2

Poor

What was your first impression of the sign?

I thought it was a good idea

What do you remember?

I don't remember the exact wording of it - it was saying you're in good health or you're tuned up or something to that effect

How many times have you been by the sign?

probably twice in the last three months

Did you understand it at first?

Yeah, I could see that, and I thought it was a good idea - let people know

Did you notice the message at the bottom of the sign?

No

Did you notice a second sign?

I don't really remember it - I have a vague impression of seeing a phone number, but I don't remember seeing a separate sign

Would you have liked an earlier sign saying what was coming up?

I don't think it would have helped

Did you find it hard to see the sign? Why or why not?

No, going down Speer sometimes can be pretty hectic, so if you're not paying attention to traffic it's easy to see, but if there's a lot of traffic going on, it could be - probable paying more attention to traffic than to the sign

Describe your experience on the ramp?

Came off I-25 and just happened to notice it

Why do you think the sign is there?

I've been hearing a lot lately about when to tune automobiles and the brown cloud and I sort of thought it was somebody's idea just to remind people to tune up their vehicles or at least keep them clean

Do you think anyone is going to do anything as a result of the sign?

90% of the people probably wouldn't, but I think the others would be interested in knowing cleaner air, curiosity, certainly costs less to have a well running vehicle - I found that out a couple of times

Have you done anything as a result of the sign?

No, in the last year I probably haven't driven the car more than 2,000 miles mainly because I've been out of town a lot on business and since this last tune-up it just hasn't had that many miles on it.

What do you think about the brochure?

I think it looks pretty good to me

Would you have liked to have seen the brochure before driving past the sign?

I think I would have - yes - then I'd know it was there to look for it

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, I do

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Yes, I do

How much would you be willing to pay to fix your car so that it falls into the good category?

I really don't know - I've never really had any problems with emissions test - well I get a tune-up every year - 100-200 dollars

What is the air pollution problem?

half of it is particulates and the other half is general auto use - all of the carbon monoxide, the nitrous oxide that comes out of it

Do you believe that the "brown cloud" is caused by the carbon monoxide emissions from vehicles?

some of it is car pollution and some of it is particulates - I've lived here all of my life and I've noticed it developing and the big cause is that more people have come into town - the city has probably doubled since I was born

What do you suggest we do about the problem?

I don't know if there's any one good solution - I think people have worked on cutting particulates as much as they're willing to give up - from the rubber coming off of tires to sand and gravel operations - cars, all good, running cars

If the bus was accessible (for example, if the bus stopped within 2 blocks of your home and work), would you pay \$10 dollars for a monthly bus pass? (If yes to \$10 dollars, go to \$20 dollars, if no to \$10 dollars, go to \$5 dollars).

mass transit - doesn't seem to go where I want to go - there isn't one central business or industrial center anymore, it's scattered out in so many different places that RTD has a real problem getting anywhere - I don't take the bus, because it doesn't go where I want to go 95% of the time - 5% of the time, I've looked it up in schedules, it would take me 3 to 3 1/2 hours to get to some places I need to go

Yes, would pay \$10 dollars a month

If it was possible that the RTD could be subsidized through a gas tax would you be more willing to use the system? For example, the government collected 2 cents on every dollar spent on gas, and the money was used by a private bus system.

a lot of it is a time factor and convenience - the nearest bus stop to where he meets is a mile and half

Would you be willing to participate in a program for an emission based registration fee program? (for example: If you were charged x amount of dollars per 100 grams of CO, based on the number of miles you drove that year, would you accept that as your registration fee? This cost would provide revenue towards mass transit. Also, you would be granted a refund of \$50 dollars if your car's emissions were under a standard level.)

interesting concept - yes, I think I would go with that

In general, do you have confidence in the work that the government does?

In general, yes

Do you have confidence that the government can improve the air quality?

they can improve it by enforcing regulations, on the other hand there are a lot of people who don't want those regulations or would fight it, some of them who just don't feel like doing it - my problem is I have to go to all kinds of places over town so I would object if they said you can only go here at a certain time

Case #3

Poor

What was your first impression of the sign?

I thought it was gimmicky, it's not scientific - certainly because you don't have a random sample - it's meant to raise consciousness - I know enough about the politics that there is a controversy between Jerry Gallagher and Don Stedman - Don won this round sort of, they gave him this

What do you remember?

I remember the car, it either smiles or frown, everyone remembers that, right - it says good, fair or poor, costing you money - there's another sign that says for further information and I know that there's a sensor further back along the curve there

How many times have you been by the sign?

hundreds, I work down here

Did you understand it at first?

I knew that the thing was a sensor and I knew it was going to translate information to some form I didn't when they first started putting it in whether they were going to simply collect data in a database or if something else was afoot, but then I saw the sign

Did you notice the message at the bottom of the sign?

costing you money or saving you money - I very rarely have had saving you money

What was it like seeing the sign?

you can't miss it

Would you have liked an earlier sign saying what was coming up?

I don't think you can do that very easily on that spot - it's a tight curve and you're not going to be able to - it's a bad intersection to begin with - more signs would be distracting

Describe your experience on the ramp?

you know there's not much to experience on that ramp - you just go around the ramp - you know how many times I've been up that ramp since I came to work here in 1981

Do you like the sign?

reading emissions remote, by that method, is not going to work - I know Don Stedman thinks it's going to work, but I don't think it's precise enough and I know it's not precise enough because I got all three readings on my car - I've got a 1982 Toyota Tercel and depending on whether I just had it tuned up, whether I'm accelerating or not, I get different readings so it doesn't tell me that much and also the emissions standards are different for my car, which is an '82 - I don't think that the sign is reading that - I don't think it has any real scientific validity - maybe there's a handful of

guys whose going to take their car in to get tuned because it says' poor, mostly they're just going to wait to get it tuned up anyway maybe they'll bring it in a week early or so there is some minor advantage - I don't think there's one

Did you receive a brochure?

No - I'm going to take my car in to get tuned in the next week or so and we'll see if it changes

What do you think about the brochure?

yes, it tells you about the sign - some of them might get it and just go by there to see if it works - but I don't think that many people are going into central city for that- if you're going to a Rockies game

Would you have liked to have seen the brochure before driving past the sign?

No, I'd have to take that route whether I did that or not

Do you agree or disagree that keeping your car well-maintained actually saves money?

it's a function of how much to maintain it compared to the price of gasoline at a given time and maintaining it isn't that simple of a term - it's how often you maintain it -

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

yes, car maintenance can reduce air pollution

How much would you be willing to fix your car so that it falls into the good category?

very little - dollar and a half - wouldn't do all that much - to be honest - problems with air pollution are going to be solved - has an '81 tercel with 250,000 miles not much you can do about an older car that is not as good in terms of pollution - standards for 96 and 97 vehicles are a lot. higher - fuel injected system is a lot cleaner than the carbureted system

best solution?

producing more fuel efficient cars (number 1)

working on your land use if you need one container of milk, or an egg - you have to get in your car - you have to have land use that includes neighborhood stores

mass transit?

will eventually help - but it takes a long time - if you put in a rail transit system and you jiggle your zoning around so your employment centers and your shopping centers are close to the stations and eventually 50-100 years you will have land use that will be more fuel efficient, or more sustainable land use - but it takes a long time - that is not the quick fix -but it will ultimately work - you're still going to have people driving cars - you're never going to be riding on trains is crazy - big shopping centers (King Soopers) are functions of cars - you can't bring 8 grocery bags on a train - it's conceivable you could get on a train with a Christmas present - or something of that kind (clothing)

air pollution problem?

I don't think you have a very serious air pollution problem and I say that because I'm 50 years old on Friday and I can remember when I was growing up in New York City what air pollution was like - on a

summer day if you went downtown and you took a handkerchief and wiped your forehead it would be black - you don't have that anymore - compared to that and what I've seen in my lifetime is a dramatic reduction of air pollution so you've got a few carbon monoxide exceedences and I mean a few, you got the brown cloud, which is an inversion problem, which is a land use problem - you chose to build a city in a place with inversions - if you built a city where the air pollution would blow away it would dissipate - you've got a particulate problem in the winter, especially when they sand the road - but again studies don't show the causation between the particulates and for example, asthma - it's a nuisance, it's ugly, but I don't see that much of an air pollution problem anymore - it could get worse - if you keep having the growth we've been having then you're going to see the carbon monoxide come back to dangerous levels

bus pass?

That's hard to say because sometimes I need my car for work - there would be times I might use it - but the way it is now, you're talking about an additional hour and half on my day if I use the bus - (more of a time factor, not a money factor)

subsidize?

same answer (time, not money) - except rail

rail?

you have a whole different ball game - rail saves you time - can work on a train - I can read - I can't read on a bus, I get sick - if I had a train from Boulder to Denver I could get through the New York Times and the Wall Street Journal in that time - I gain time on a rail whereas it costs me time on a bus would pay \$10 dollars for a monthly light rail pass - would pay \$30

it's conceivable, if you had rail, that some people who have 2 cars now, could have 1 - with \$30 per month it's worth it

emission based registration fee program?

I'd make sure my car was tuned up before I go and pay for my registration fee - if it was every 2 years, there's no guarantee that I would keep it maintained after I pay the registration - you would have a real enforcement problem on that

willing to pay for an emission's test?

same as he does now

In general, do you have confidence in work that the government does?

yes

In general, do you have confidence that the government can improve the air quality?

yes, the EPA did - as I said, what it was like when I was growing up and what it is now

Case #4

Poor

First impression?

I heard of it before I saw it - I was three quarters around the corner paying more attention to the guy in front of me - so I just glanced at the sign

What do you remember?

Basically, it didn't approve of my car

Did you notice anything else?

Flashed a poor reading - not really, it was an ugly sign, that's all - haven't been that way again

Did you understand what it was about?

Yes, it was trying to discourage me from driving my old car - but it didn't offer any cash to buy a new one

Did you notice any message at the bottom of the sign?

No

Did you notice a second sign?

Now that you mention I do seem to remember a second sign, however since I already figured out what was going on, I didn't see the need to make a call

You thought it was easy to see your reading?

If I was going about 20 miles per hour slower it would've been

Would you have liked something else on I-25, a sign?

Earlier on the corner, but not on I-25 - there's enough going on as there is - not really sure about another sign

Describe your experience?

A little surprised - I heard of them, but didn't know, hadn't seen them before - however I think that's the type of thing they should have for pollution checks instead of this expensive, rip-off they've got going - because they could take the reading, the license number and they could determine the type of car and whether it was in and out of specs and notify the owner to fix it

Why do you think the sign is there?

Probably for a study of some sort - probably what you're doing

Raise public awareness?

I don't know - I doubt it has anything to do with raising public awareness - public is very aware - they've been ripped off every year and they don't forget that as easy as politicians like to think

Operational Problems

Problems encountered during the test were varied. Soon after the Smart Sign was activated Denver received a large amount (for Denver) of rain. Since it had been dry during most of the construction, this new moisture resulted in a large amount of settling to several of the sensor sites. This caused several operation outages during May and required the sensor systems to be realigned after each rain. In October a vehicle knocked over the light pole on which the LPR system was mounted. The accident only caused minor damage to the environmental housings for the strobe and camera but destroyed the wiring and electrical conduit attached to the pole. New conduit had to be installed and also new wiring was installed. The LPR system was down for a month while these repairs were being made.

During the winter of 1996-97 the system has operated during several snow storms and has experienced sub-zero temperatures on several occasions. What we have learned is that below zero degrees (F) the conditions are such that the system cannot maintain a high percentage of valid measurements. The combination of road sanding and vehicle exhaust condensation plumes sufficiently interferes with the beam to limit the Smart Sign operation. Above zero degrees, and with a dry roadway, the system operates normally. Usually the Smart Sign display is affected during and after a snow or rain storm until the roadway adequately dries. After the instrument recovers a valid completion rate of measurements (80% valid or above) the Smart Sign display is turned back on.

To date we have experienced only one known instance of vandalism. The remnants of a white paint ball were visible for a short time during the summer on one of the lower edges of the sign's polycarbonate shield. No one has defaced any of the above ground equipment with graffiti despite our being located within 0.5 mile of Federal Blvd. which has Denver's highest incidence of graffiti. We are aware of no traffic control problems associated with the Smart Sign's use but were made aware by two construction workers that the public's interest in the Smart Sign's had made their job's more difficult. During October and November a sidewalk was replaced and installed *over* I-25 on Speer Blvd. This required the traffic to be stopped on the exit ramp to allow trucks to enter and leave the site. The flag people were required to be more animated and visible to attract the attention of drivers on the ramp because of their interest in the Smart Sign. The sign itself has been maintenance free to date.

Statistics

Through December 1996 the Smart Sign, which began in May 1996, system has measured more than 2 million vehicles. This location is a very busy interchange and is one of the major gateway's into downtown Denver. A major university, amusement park, major league baseball park, many state government offices in addition to many of the downtown businesses are accessible via this interchange. Figure 5 shows the average Smart Sign volume by day of week for days that the system was operational. Figure 6 shows similar data graphed against hour of the day. One factor which affects these values is the amount of time the LPR system was used. With the LPR functioning daily vehicle counts are depressed approximately 15%

How much would you be willing to pay to fix your car so that it falls into the good category?

In my particular case I didn't spend a dime because it was already running good - for the older cars it is not practical to go down and get an overhaul because the sign said so - if you have a '96 and it fails you better take it in and get it fixed because there is something seriously wrong with it -

Envirotest if it failed? - usually, what you do is unplug a vacuum line hose and that will put you into compliance or you can go to a different Envirotest - they report to be very accurate, but the repeatability is very poor

What do you think is the main air pollution problem?

-Dust - the brown cloud is dust - not as bad now as it was in the '70's - because of public service using natural gas now instead of coal and they don't use as much sand now as they used to - particulates are the definitely the biggest problem - the carbon monoxide, I think, is irrelatively innocuous - for years, remote sensing in Denver, they'll used a dome to measure the flowthrough and a lot had to do with which way the wind was blowing - to measure the city as a whole you have to pull your sensors off the road quite a ways to read. the mixture up there - of course as soon as you do that the city would be in compliance all the time - you have the maximize the problem so you have a reason for being in existence

What do you suggest we do about the air pollution problem?

I don't think there's a need to do anything - the problem is going away by itself

- the pollution tests have had no effect, it's just a way to milk the customer

Would you be willing to participate in an emission based registration fee program?

Absolutely, I can pull off lots of hoses - interesting concept, but I would be against it because I can't afford a new car

It's a problem that's going to go away (Air pollution)

Do you have confidence in the work that the government does?

No

Do you have confidence that the government can improve the air quality?

Absolutely not, the government never improves anything - whatever it gets into, it screws it up

Table III. Smart Sign operational activity by month.

Month	Monthly Hours (Operational Hours) Percent	Comments
May	384 hours (270) 70%	Startup problems and diggings settling caused by heavy rains.
June	720 hours (687) 95%	
July	744 hours (662) 89%	Electrical problems with detector start.
August	744 hours (648) 87%	Detector failures increase.
September	720 hours (667) 93%	Software upgrade to detect and restart after detector failure.
October	720 hours (653) 88%	57 hours of operation lost due to local construction interrupting power.
November	720 hours (681) 95%	
December	720 hours (503) 68%	18 1 hours of operation lost due to local construction interrupting power.

How did you feel about seeing the sign?

I felt good about it - I received a good rating - had I received a bad rating, I would've been concerned about, what happens now

Helpful? (sign)

Very

Do you think anyone is going to do anything as a result of the sign?

It has a lot to do with the funding - we're either going to keep the funding we have or lose it

Do you think individually anyone will do anything about their car?

In my experience, those of us who carry insurance, and take care of our vehicles and are more apt to take care of things will probably do something - those who don't have insurance, hey, this car gets me from Point A to Point B, what more what more do you want me to put in it, I think you're talking about different levels of attitudes - and I can't define it as responsible people, because maybe those who don't carry insurance, maybe are responsible people also, but for some reason or another, they don't have insurance or they can't update their car or fix it for some reason, in which case they might be working at it - I just think there is a difference in attitude

What do you think about the brochure?-

Pretty direct, pretty simple - not busy, I like it - it has the same little picture I can identify with

Would you have liked to have gotten that before?

Yes, I would have looked forward to what my reading would be as I passed it - good job, pretty clean

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, you have less maintenance, less high priced maintenance

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Absolutely, keeping the engine clean making sure all the parts are working - makes your car run much better and doesn't create that pollution

How much would you be willing to pay to fix your car so that it falls into the good category?

Nothing, but, depending on what the fine would be, I guess is what I would have to react on, and if my license plates were to be given to the Division of Motor Vehicles for having a polluting car and I was to receive a \$20 dollar fine or \$500 dollar fine, obviously that would stimulate my effort towards getting that car fixed - so that depending on the cost of the fine

What is the air pollution problem?

Vehicles, tons of traffic - I've worked downtown for twenty years and I've seen an increase in traffic grow unbelievable - vehicles are the majority of polluters

Contributes to the brown cloud?

Yes

PERFORMANCE:

FUEL ECONOMY

Since 1980 all cars and pickups are made so they should register "GOOD". Older vehicles may read "FAIR". Any vehicle of any age which reads "POOR" is not burning its fuel at the best efficiency.

If your car reads "GOOD", proper maintenance to keep it that way will save you money.

If your car reads "POOR" skilled diagnosis and repair will pay you back in improved gas mileage.

EMISSIONS

GOOD FAIR POOR

The sign provides you with a measure of your vehicle's carbon monoxide (CO) emissions.

Most vehicles are well maintained, have very low (GOOD) CO emissions. They are burning their fuel efficiently. Good maintenance can save you money.

POOR CO EMISSIONS means that diagnosis and repair of your car can pay for itself in a few months because of better gas mileage.

POOR CO EMISSIONS means that the exhaust of your car is polluting the air. CO is DEADLY POISONOUS at high concentrations.

DRIVEABILITY

If your car is 1980 model year or later it was designed to drive best with less than 1% CO in the exhaust "GOOD" all the time when warmed up. High CO, "POOR" always indicates poor fuel economy and often poor driveability too.

If you get a "POOR" reading do your bit for your pocketbook and Colorado's Air. Have your vehicle carefully inspected and repaired if necessary.

Case #6

Poor

What was your first impression of the sign?

Didn't hear anything about it - didn't know anything about it - and even when it smiled or Crowned at me I thought well, what is that all about and then as I drove by it more, my awareness, I was able to recognize what it was trying to do, now how it did that I didn't know - I assumed it read opacity or some kind of a thing like that, then correlated when it said poor, they're talking about me, so then I kind of developed a conscious about it and if you can avoid it, you make a non-conscious choice to avoid it - it kind of gives you a conscious I guess

What do you remember?

I remember seeing a few frowns then I thought maybe I should look at it myself, but I didn't get around to it - the conscious wasn't enough to drive the motivation to get it corrected

How many times have you been by the sign?

50-60 times

Did you understand it at first?

No, not at first- maybe after a week or few days then I recognized it's telling me about my vehicle and I don't remember specifics how the sign tells you the information

Another message, message at bottom?

No (probe) - oh yeah, I do remember, costing you money

Remember a second sign?

No

Pretty easy to see?

Yes, very obvious

Would you have liked an earlier sign?

Maybe it if it was immediately on the on ramp where it didn't distract you, it probably would be good- there's only so much information you can digest in an amount of time- if it was spaced at an interval, ok

Experience? (on the ramp)

Generally went to work early in the morning distraction was that big of an issue

**An efficient vehicle
saves you money.**

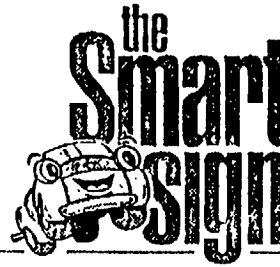
FOR MORE INFORMATION, CALL:
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TAILPIPE EMISSIONS ANALYSIS AHEAD

A Free Public Service

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Questions & Answers



A. If your vehicle measures GOOD, this means your car or truck is generally well maintained and emits very low levels of carbon monoxide (CO) into the air. If your vehicle measures POOR, it means that dangerous, invisible CO gases from your exhaust are polluting the air.

A. If your vehicle was manufactured before 1975, you can anticipate getting a FAIR reading. If your vehicle was manufactured after 1982, you can expect a GOOD reading. In all cases, however, a POOR reading means your vehicle is a polluter and needs repairs.

A. Quite probably. And studies have shown that such repairs often pay for themselves in just a few months because of improved gas mileage and overall vehicle performance. In most cases of excessive emissions, basic repairs solve the problem.

A. Most new vehicles have GOOD readings all the time. But as vehicles grow older, parts begin to wear out, causing variable CO emissions. The Smart Sign measures those varying emissions and consequently provides varying readings. In virtually all cases, repairs eliminate such variance.

A. The Smart Sign program is informational only. It is intended to alert motorists to the condition of their vehicles so they can take voluntary action to correct a problem if one exists. There is no enforcement.

A. For one thing, motorists can get a quick assessment of the mechanical state of their vehicles without going through a formal emissions test. Smart Sign also allows you to verify whether or not mechanical repairs were correctly made and does so at no cost. The single most important benefit of the program, however, is the heightening of awareness and concern about air pollution issues.

A. No. You must still present your vehicle for Colorado emissions testing as required by state law.

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What do you think causes the brown cloud?

A lot of it is geographic - it's accentuated because of where we're at - L.A has the same problem we do - it looks worse - a study done in '80 or '85 and said that most of the brown cloud was due to particulates - so I say mostly particulates

What do you suggest we do about the problem?

What they're doing now - how do you avoid that, you can't - you can't walk away from it, you have to have it yearly or every two years

Mass transit is a real solution - it is the solution - how that's funded is another set of works
- convenience is the height of the issue

If the bus was accessible would you pay \$10 dollars for a monthly bus pass?

probably - but, sometimes your on a schedule, but with my work, schedules change and buses aren't very conducive to anything other than a very strict schedule

Would you be willing to participate in an emission based registration fee program?

Can't imagine the government giving back \$50 bucks - increase the operating cost of a small business,' unless there was another set of rules

In general do you have confidence in the work that the government does?

No

In general, do you have confidence that the government can improve the air quality?

No

One final and very important issue that did emerge in the discussion was the problem with the black plume. As an educational sign, it sends the wrong message, especially about invisible carbon monoxide. Several alternatives were suggested including making all of the background black and using colored LEDs to form the appropriate colored plume depending on the reading.

However, the most exciting alternative to emerge was to change the picture and not rely on a plume to convey the message. The basic components of the new picture would be:

SMILY CAR LOCATED ON THE LEFT

CAR ON WINDING ROAD

CAR EMITS EXHAUST "BUBBLES."
that are in appropriate colors
and lead to a roadside sign

ROADSIDE SIGN in black background
that designates GOOD-FAIR-POOR
in appropriate colors

This concept needs serious graphic work but holds promise.

- Brochure. The other significant discussion that occurred dealt with the content of the brochure. Two alternatives were provided. One was conceptualized several months ago and the other was recently put together to account for the shift from "emissions" to "performance". A number of thoughtful suggestions were offered.

- Doesn't tell you-to do something. No clear explicit message.
- Doesn't address the what to do, how to do it, where to do it type of questions.
- Too wordy.
- Needs facts for both educational and motivational value (e.g., "The average car costs you \$100 or more if not tuned properly", "X thousand people a year suffer from pollution related illnesses").
- Needs to be more on fuel economy.
- Use more graphics and pictures.
- Explain (educate) on carbon monoxide.

What do you think about the brochure?

Nice - would be interesting to find how they monitor cars before 1982 - knowing that, I didn't put a lot of weight into my reading - also it's an upgrade opposed to a flat driving space

Would you have liked to have seen the brochure before driving past the sign?

I would have - it's nice to have an emissions test that you don't have to pay \$15 bucks for

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, better gas mileage - I do my own car work - on the other hand, after a certain age the amount you're spending on the car is more than it's worth

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Yes, car goes out of tune, timing goes out of tune - more pollution

How much would you be willing to pay to fix your car so that it falls into the good category?

\$300 - a hundred more after an emissions specialist - owns a Jaguar

What is the air pollution problem?

cars and growth - some meteorological conditions, but mainly it's cars on the road

more specifically, what type of pollutants?

I don't know

What do believe causes the brown cloud?

I assume most of it is from vehicle emissions or particulates from gravel - general turbulence

What do you suggest we do about the problem?

What we're doing now - federal standards

Better solution?

mass transit?

bus takes too long - people enjoy their cars (and here's the result - as he looks out the window - brown cloud, haze)

Would you be willing to participate in a registration fee program?

people would unhook their speedometers - nice idea though

In general, do you have confidence in the work that the government does?

Yes

In general, do you have confidence that the government can improve the air quality?

yes, are able to enforce regulations

UNIVERSITY OF DENVER

Department of Marketing

MEMORANDUM

DATE: October 16, 1995
TO: Neil Lacy
FROM: Bruce Hutton *BH*
RE: Summary Report: VMS Expert Focus Group, 10/16/95

In response to issues regarding the variable message sign, we conducted a second "expert" focus group at D.U. on October 16, 1995. The three objectives of the meeting were to:

1. Revisit sign content, in terms of specific words used to convey our message in a way that avoids confusion with other programs and relates to the purpose of the study.
2. Examine collateral communications sources in terms of their purpose and to ensure message consistency.
3. Identify media and public relations issues and how to manage them.

In summary, the one and a half hour session was very useful. Most of the attention was focused on the first objective with a brief discussion regarding the brochure. Communications issues relative to the hotline and radio were not addressed, nor was the media/PI3 issues. It was suggested that follow-up meetings, possibly in smaller groups would be useful.

The meeting consisted of 12 participants. Represented were CDOT, CDPH&E, Skyline, D.U. and a number of experts in the communications field. Following is a summary of the conversation and conclusions.

- Sign Concept. The purpose of the sign was defined as motivating the public to first obtain more information through accessing the hotline number. Second, the sign should be educational in and of itself. Third, it should encourage seeking assistance if the car rating is "Poor".

Response to the sign was very favorable. The car and changing face was viewed

Describe your experience on the ramp?

I was totally surprised because I had no idea that was in Denver at all and then I kind of went, oh dear, what does that mean

Do you think anyone will do anything as a result of the sign?

Oh there might be somebody who will say I need a tune, but as a volunteer thing, not much, I mean it certainly didn't make me go out and do anything to it, but then again he didn't tell me anything I didn't already know - I know the engine on that thing is bad and it passed emissions not too long before going by the sign - so it made me wonder how poor, poor was and how bad the standards are for those tests if I pass the test and I go by there and I get flagged as being poor - that's the only thing the sign didn't tell you- what does poor mean

What do you think about the brochure?

so it had saving you money on it? (asked by the interviewee)

I don't see the pollution thing as saving you money or costing you money - I disagree with the statement - saving you money, costing you money - because I have had the tailpipe stuff and passed those in other states and then you change it so now it runs better and gets you better mileage, but if you tune it up for passing the emissions, it runs like garbage and idles like garbage and as far as I'm concerned it's costing me money - I don't believe the message and therefore, to me that detracts from the purpose - the real purpose, let's face it, is to clean the air, not save you money, and when that says poor, all that means is that it's going to cost me money because I have to go out and fix something - I got hit for almost \$600 in repairs to pass an emissions test, so if I go by and I see that this thing is poor - I don't see this as going to cost you money, waste you money because your driving, I see a sign saying I'm going to have to pay a whole bunch of money to get your car fixed, so I think the message is opposite - and the real truth is you're trying to clean the air, and I think more people care about that then the nebulous value of maybe you're saving money - the sign was clear and easy to see, but if it said that about the money, I don't remember it, but I can tell you my response to that immediately - that means somebody is trying to brainwash me - it isn't true - or if it is, for me it's going to be the opposite - to get it to saving me money I'm going to have to take money out of my pocket

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes - in the long run - maybe changing your oil so you don't have to pay for a new engine later - most of the cars I have are so old and beat up- their never worth fixing anyways - depends on what kind of car you have - how new it is

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

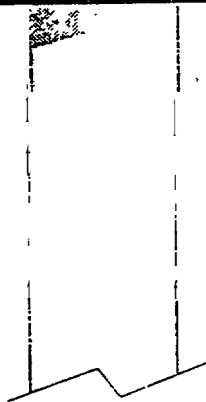
Yes - well, if it's running right it's not going to pollute as much

How much would you be willing to pay to fix your car so that it falls into the good category?

there are two real problems in terms of auto emissions or vehicle emissions - the first one is the incredible amount of diesel vehicles out there that pollute like crazy - I mean I've gotten behind some of these city vehicles and buses, school buses, whatnot, and you can't even breathe - I mean you breathe when you're behind them, they're so bad and yet I'm supposed to maintain a vehicle to pass and nobody can smell it, nobody can see it, nobody can indicate unless somebody does some test like you

TAILPIPE EMISSIONS READING AHEAD

A Free Public Service



Would you be willing to participate in an emission based registration fee program?

And how are they going to monitor it - and the last thing people want is the government watching everywhere you go

In general, do you have confidence in the work that the government does?

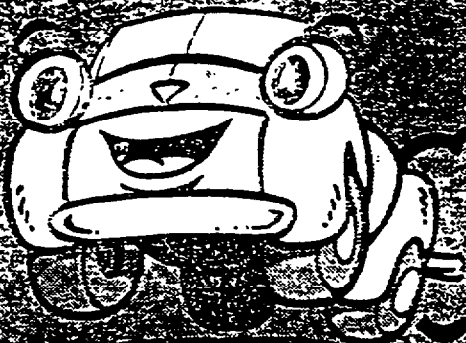
No

In general, do you have confidence that the government can improve the air quality?

No

I hope the end result is that we end up with a passive system instead of the going down to Envirotech - so I hope you get your signs and your passive things and someday I'll get caught

YOUR EMISSION IS:



GOOD

POOR



Saving You Money!
\$\$\$

**An efficient vehicle
saves you money.**

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Do you think, in general, anyone will do anything as a result of the sign?

I have no idea - I probably would have

What do you think about the brochure?

I think it's informative - it's too bad they don't have these in other places

Would you have liked to have seen this before you went by the sign?

Wouldn't have made a difference because I don't normally travel that route anyway and that was just a couple of times that I just needed to go down there - I saw the sign the first time, then I read 'about it in the paper, then the second time I knew what was going on

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, I do agree - because if you have a car that is an efficient fuel user like I know mine is - you don't have to spend as much on gas - all the parts that are connected with everything don't get as dirty - the car runs longer - you get better use of your car - you can keep it longer

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Yes I do, I agree that it can - if you have a well-maintained car it uses fuel more efficiently so you're not throwing out unused fuel into the atmosphere which is what is really happening

How much would you be willing to pay to fix your car so that it falls into the good category?

I don't know, tune-ups usually cost us - you know a good tune-up would do a lot of it probably - it usually costs between \$200 and \$250 dollars

In your opinion what is the main air pollution problem?

Vehicles - in Denver anyway - along with that though is, that contributes to that would be bad timing of stop lights and also the curvy, low streets that you sometimes have to go on - when they build neighborhoods now - I know my neighborhood is fairly good, but a lot of neighborhoods you get into they built these pretty little streets and they build lots of cul-de-sacs and lots of places where you can't get through and that makes people go slower and it causes a lot of unnecessary travel and slowgo travel, I think is part of the problem too

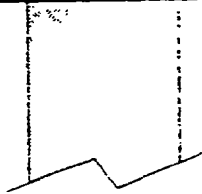
What do you think causes the brown cloud?

Primarily, at this point in time - I would guess that it's two things - one of them is the vehicle pollution, which I think is a really serious problem because I drive quite a ways to work myself and I know a lot of people do and highways are clogged and it's a problem - and another thing I think is just a dirt and dust problem - you know, because we do have, you know if the wind picks up around here - a lot of times if it blows pretty hard you've got a lot of dust and so that stuff gets kicked up in a regular day when you don't even realize it

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with the National Science Foundation, Colorado DOT and the US DOT.



Case #10
Good/Fair

What was your first impression of the sign?

First thing I thought of was the professor at DU, I wondered if that was his project - I had seen him on the news before

What do you remember about the sign?

I go to school at DU and UCD and drive through there all the time - I know my Mazda hits good all the time and hits fair once in a while and my Chevy hits bad all the time - good, saving you money - fair, costing you money, and bad is wasting you money

So, you've been by there many times?

Yes

Did you notice a second sign?

It had the phone number on it

Did you call the phone number?

No, I think I wrote it down one time - I meant to call, I was curious about it - I think they moved the phone number now, too

What was it like seeing the sign?

I think it's fine, the way you've got it timed, where you go through, and by the time you get to the sign, it flashes whatever it evaluated your car as

Would you have liked an earlier sign stating what was coming up ahead?

Maybe something so they know what to expect - the first time I drove I saw the sensors, so I knew there was something to look for - maybe for the average person, a sign telling them pay attention to what's ahead

Why do you think the sign is there?

There's a lot of concern about air pollution so it's to gauge in one spot what it's like - get an average number of cars that are polluting - curiosity, too - I suppose

How did feel about seeing the sign?

It's kind of like the signs they have set out for speeding to actually see how fast you're going- I'm sure there's going to be a few people who are going to see that and probably be more concerned with how their car is doing - for me, my goal is to drive my Chevy 2 liter and have it say good one of these days

APPENDIX B

VMS Alternatives

What do you suggest we do about the problem?

Have everybody ride their bicycles - I don't know, I think about that allot - there are just so many cars on the road and one of the things I think about is why we haven't run out of oil and gasoline - I don't think it matters what little you try to do, I just think it's going to get worse - I just think the average person is more concerned with themselves than the environment or anybody else's rights and I think they probably feel, well I think they're selfish in that everybody else should, you know get more fuel efficient cars, they should cut down driving and stuff, but I don't want to, I want to do what I want to do - pretty much, the majority of people have that attitude - they agree that something should be done - they agree that it is a problem, but they don't want to sacrifice any of their time or anything like that - I think unless it gets really, really bad and there's actually laws passed, I don't think it's really going to change that much, unless they go like methanol fuel or electric cars or something like that where it's just like fuel prices are too much and the cost of driving a car is too much, the alterior would be to ride a bike

the best solution would be mass transit, but I don't like it - I prefer to drive myself, so realistically, I think a car that pollutes less is the alternative and it's got to be competitive with prices right now

Would you be willing to participate in an emission based registration fee program?

I think I'd like that, I mean that way the people that drive a lot would have to pay for it where somebody that doesn't drive that often would have to pay less - I think that's fair - people that drive more do most of the polluting

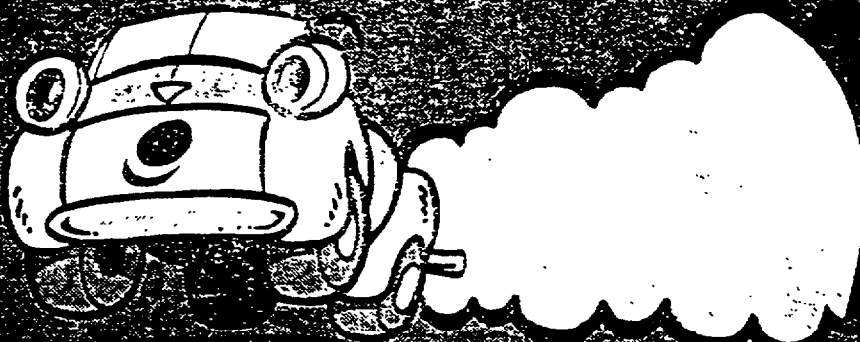
In general, do you have confidence in the work that the government does'?

No - I think it's too big - I think if they broke it down - maybe divide our one country into three countries - the east coast, the west coast, and central, and have three presidents

In general, do you have confidence that the government can improve the air quality?

No - I think, on the surface it seems like they're improving, but big corporations get away with a lot of stuff that the smaller businesses can't and the people that are willing to shell out the money are going to get away with it

YOUR EMISSION IS:



**An efficient vehicle
saves you money.**

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Do you think it's good, helpful?

Yes, if you see more of those things around I think it would be helpful, people would actually think about it if it says, it's costing you money - people don't want to spend more money than they have to - and if they actually had something like this that tells them their car's in poor health it's something that's simple too, because driving by instead of going to the emissions testing place

Do you think anyone is going to do anything as a result of the sign?

Yes, I mean I know I would if I saw my car was in poor health I would want to do something about it you'd want to figure out what the problem is

What do you think about the brochure?

This explains what each of the readings say - I think this would be good to have for people - I think that something like this would be really useful if you're at a Conoco and it's around the sign, people will see the sign and like to see what it's about - a little paragraph about each thing lets people understand what the reading is, what it means

Would you have liked to have seen that before you went by the sign?

I think it would be better to see the sign first, because it kind of catches your eye when you actually see it - when you just see a brochure like this without seeing anything first, what's this?, but if you've seen the sign, then the brochure, you might want to pick one up and see what that's all about

Do you agree or disagree that keeping your car well-maintained actually saves money?

I agree because with the cars we have now, they are junk pots anyways, if we could keep them maintained, it would save us a lot of money - it seems like even though we have everything breaking down somewhere on the car, if we would just pay a little attention to try and keep it maintained, to keep it in better health, it would save us a lot of money because we take it to a shop, a service station all the time, it really costs us a lot of money - it's phenomenal how much we pay for these things - it gets to be a lot after a while

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

I think it can, if you keep it well-maintained then most of the parts will work properly, you won't have the wrong kind of emissions coming out of the car, if everything functions normally, the car won't have that emissions - if everyone would do that - I mean you think about it, one car, it doesn't really make a difference - if everyone kept their cars well-maintained it really would make a difference

How much would you be willing to pay to fix your car so that it falls into the good category?

Depends on really what was wrong with it - If it was more than the car was worth I'd scrap it - I would want to try and get it fixed to begin with, but if it started getting up there to the amount the car was worth - might as well just get a new car

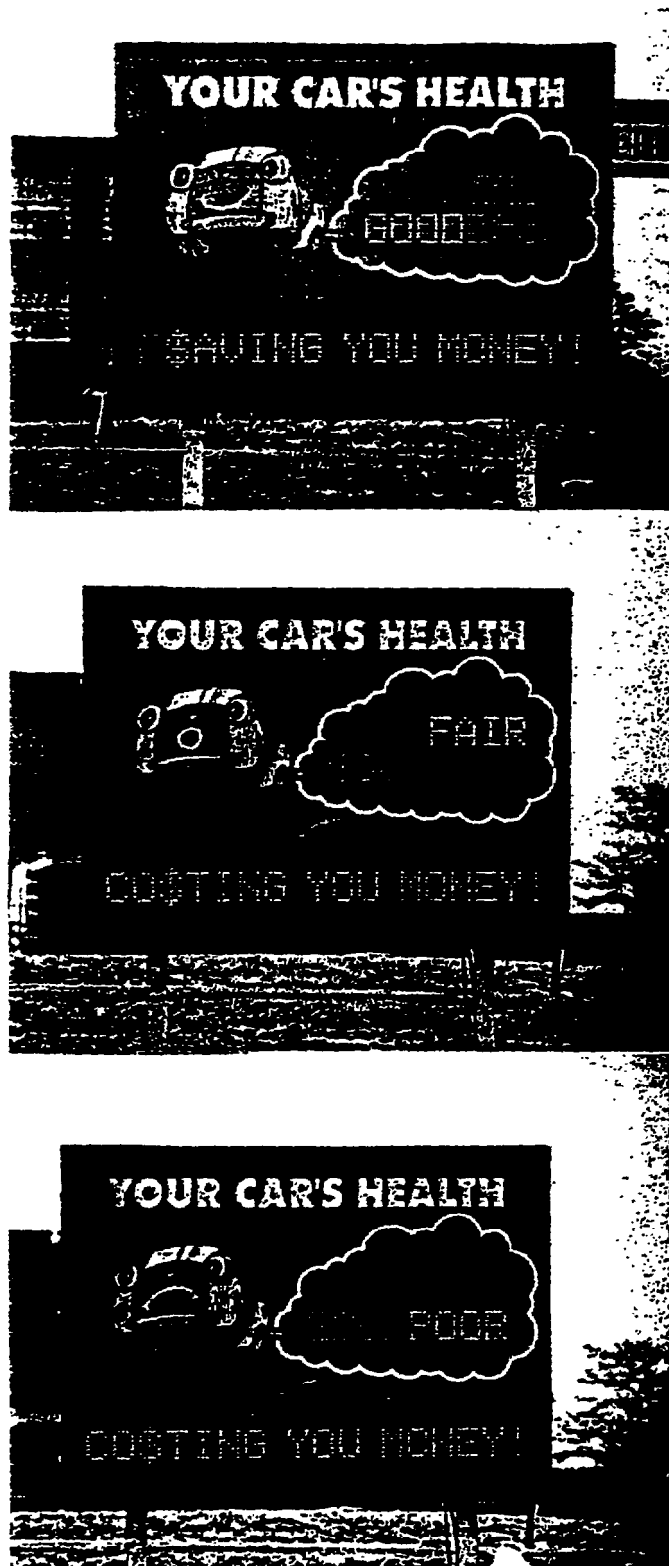


Figure 3. Photography of the Smart Sign as deployed. The top photo displays the **GOOD** message the middle photo the **FAIR** message and the bottom photo the **POOR** message.

Case #12
Good/Fair

What was your first impression of the sign?
I thought it was pretty neat

What do you remember about it?
Actually, the first time I saw it, all I remember is the sign, but the second time I remember seeing the monitor on the ground - it had the funny looking red car - it was kind of small - first time I went by it I got a good rating and eventually I got a fair rating so I gave my truck a tune-up

How many times have you been by the sign?
Two days

Did you notice a message at the bottom of the sign?
No

Did you notice a second sign?
After the first one, yes, a smaller blue sign, yea

Did you call the phone number?
No

Do you think the sign is pretty easy to see?
Yes

Would you have liked an earlier sign saying what was coming up?
That might be more effective - might make people more aware

Describe your experience on the sign?
Glancing at it I saw, "Good." - I didn't know what was good - It wasn't until the second or third time that I actually noticed, knew what it was doing

Why do you think the sign is there?
I think to get people more aware of the air quality around here - cars are a large part of the problem - with the brown cloud

How did you feel about seeing it?
Didn't offend me - I think it's doing more good than harm

What do you think about the brochure?
I like it - It's short, but it states the facts

all of these suggestions to mean that we needed to denote the emissions information in a variety of ways.



Figure 2. A composite drawing showing many of the design elements tested by the focus groups.

The basic design elements would include a declarative statement to describe the type of information being provided like "Your Emission Is:" or "Your Cars Health" at the top of the sign. In the middle would be our cartoon car whose facial expression would change with changing emission levels. This would be supplemented with a "GOOD/FAIR/POOR" description of the vehicles emissions and each of these emission levels would be color coded. At the bottom of the sign would be motivational message of "Saving You Money" for "GOOD" readings and "Costing You Money" for "FAIR/POOR" readings.

Implementation

Consultation with Skyline Products Inc. personal eliminated several layouts. For example the groups had felt positively toward the idea of the emissions plume behind the vehicle being color coded. This would require a large number of LED's which would put the construction price beyond the limits of this project. The design team settled on using a painted on emissions plume into which the "GOOD/FAIR/POOR" colored coded messages would be displayed. Cost constraints also dictated that the motivational messages would need to be a single color. We chose to use green and its natural link with both money and the environment.

Case #13
Good, Fair

What was your first impression of the sign?
I think I'd seen it advertised so I was waiting for it

What do you remember about it?
The smile and the frown - it was nice

How many times have you been by there?
I go by about three times a week, sometimes four

Did you understand it at first, what it was telling you?
Yes, I was aware

Did you notice the message at the bottom of the sign?
The smile - saving you money and the frown, you're losing money or something

Did you notice a second sign?
No - not until this lady asked me about it the other day

What was it like seeing the sign - did you think it was pretty easy to see?
I think it was plenty big enough - I had a little trouble picking up my car with everybody else's cars - sometimes I go through with 5 or 6 other cars and it was kind of a problem for me - I didn't know where I was supposed to read mine

Would you have liked an earlier sign saying what was coming up?
You know it might've helped - I don't know - It wouldn't have mattered - I still have to go that route anyhow - it just the made the curve interesting is all - it doesn't matter

Can you describe your experience?
I was real excited that I got a good - it made me feel good

Why do think the sign is there?
I knew it was a test - I thought it would be very interesting and I think they need more of them around - a lot of people in this area don't even know about it cause they don't go down south

Did you do anything as a result?
I got it fixed - it needed an air flow valve for \$400 dollars

current vehicle fleet. Three emission categories necessitated a three color system that would be visible in bright sunshine. The multi-colored sign is organized with red (> 4.5% CO, a gross polluting vehicle), amber (1.3 - 4.5% CO, a marginal emitter) and green (< 1.3% CO the low emitting vehicle). Amber and red LED's have been available for some time in high intensity versions suitable for daytime applications'. The Smart Sign is one of the first uses of a new high intensity green LED technology.

License Plate Reader

It was necessary for this project to conduct some type of analysis to fully determine the public's reaction to the Smart Sign. Sampling designs dictated that we would need to directly contact drivers who frequented this exit ramp. The most appropriate way to obtain this type of information was through vehicle license plate information. With a vehicle's license number it would be possible to obtain a name and address from the state motor vehicle records. This information could then be used to locate a phone number of the owner of the vehicle and provide a way to survey the opinions of vehicle owners.

An automatic license plate reader (LPR) was purchased from Perceptics, Inc. of Knoxville, TN. The LPR was mounted on a light pole at the entrance to the ramp in special environmental housings to protect it from the weather. This system is a strobe based system and uses a xenon strobe to illuminate the plate and then through image processing techniques it converts the picture of the license into its respective alphanumeric representation. The system is not capable of reading the license of every vehicle which uses the ramp due to a very limited field of view. In operation the system proved capable of reading between 10% and 15% of the vehicles that used the ramp during daylight hours. This enabled the collection of between 1,000 and 1,500 vehicle plates per day.

SMART SIGN DESIGN

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The partners conducted three focus groups in an effort to design and implement the plans for a the variable message sign and the overall design of the operational test. We sought input on key issues such the type of information to convey, the number of signs to use, their size, their motivational and attention getting properties and their information processing and learning components.

The first group was composed of a group of experts from various fields including the business, communications, graphic design, marketing/advertising, transportation and academia. This group was assembled to help narrow the field of topics to be discussed in our general public focus groups. The discussion that followed centered on three categories the group felt important, external factors affecting the effectiveness of the sign, methods and communications.

What do you believe causes the brown cloud?

It's cars, but it's also the manufacturing end of it - industry - I'm a native and I've never seen anything like it - each year it gets worse and worse - you get up to about 88th or something and look down into Denver it just makes you sick, but when I come home I can also see it out here - it's all around - dirt from construction

What do you suggest we do about the problem?

I'd like to take a bus to work, but my job requires me to go from place to place - I wish more people could take the bus - send everybody back to California and Texas - work a little harder on polluters, not only cars, but in the industry - maybe that might help - we're gonna have to do something

Would you be willing to participate in an emission based registration fee program?

It might be a good idea for the future

Also, maybe implementing the testing (Envirotest) all over Colorado (not just the six county Denver metro area)

In general, do you have confidence in the work that the government does?

Yes

Do you have confidence that the government can improve the air quality?

Yes

SMART SIGN OPERATIONAL TEST AND COMPONENTS

Location

The Smart Sign operational test is located in Denver Colorado at Interstate 25 exit number 112a. This is a single-lane uphill (4% grade) off-ramp which connects to southbound Speer Blvd. This ramp is located in the central Platte valley near downtown Denver, and Speer Blvd. is a major arterial feed for downtown traffic. This central location experiences some of the heaviest traffic in all of the Rocky Mountain region.

This site was chosen for several important reasons. It has one of the longest monitoring histories for remote sensing measurements dating back to 1989 (Bishop and Stedman, 1990). In addition the experience at this location ensures a near ideal location for conducting tailpipe emission measurements with an RSD as the successful measurement rate at this location consistently exceeds 98% for ideal conditions. Two final pluses are the close proximity to the University of Denver's campus and the fact that electrical power has already been installed on both sides of the on-ramp. Both of these aspects help to maximize the data collected and minimize the costs associated with performing the demonstration. In addition the Denver area weather includes all major types which will need to be evaluated for determining the test's suitability for other national locations.

The Remote Sensing Device

With support from the Colorado Office of Energy Conservation in 1987, the University of Denver developed an infra-red (IR) remote monitoring system for vehicular CO exhaust emissions (Bishop et al, 1989). Significant fuel economy improvements result if rich-burning (high CO and HC emissions) or misfiring (high HC emissions) vehicles are tuned to a more stoichiometric and more efficient air/fuel (A/F) ratio. The basic instrument measures the carbon monoxide to carbon dioxide ratio (CO/CO₂) and the hydrocarbon to carbon dioxide ratio (HC/CO₂) in the exhaust of any vehicle passing through an IR light beam which is transmitted across a single lane of roadway. Figure 1 shows a schematic diagram of the instrument setup.

The RSD was designed to emulate the results one would see using a conventional non-dispersive infra-red (NDIR) exhaust gas analyzer. Thus, it is also based on NDIR principles. An IR source sends a horizontal beam of radiation across a single traffic lane, approximately 10 inches above the road surface. This beam is directed into the detector on the opposite side and divided between four individual detectors: CO, CO₂, HC, and reference. An optical filter that transmits IR light of a wavelength known to be uniquely absorbed by the molecule of interest is placed in front of each detector, determining its specificity. Reduction in the signal caused by absorption of light by the molecules of interest is translated into the individual tailpipe concentrations.

An RSD can measure the CO and HC emissions in all vehicles, including gasoline and diesel-

Do you agree or disagree that keeping your car well-maintained actually saves money?

I agree - fuel economy

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

I agree - fuel efficiency relates to emissions - and how well your car is running relates to all of the above

How much would you be willing to pay to fix your car so that it falls into the good category?

Whatever it costs for parts

What is the air pollution problem?

Auto emissions - Californians

What do you think causes the brown cloud?

Vehicle emissions and it's just going to get worse because traffic has increased immensely in the last three or four years

What do you suggest we do about the problem?

Put the signs all over the place - makes people aware - don't put ethanol in gas

Would you be willing to participate in an emission based registration fee program?

Makes sense to me - I don't have a problem with it

In general, do you have confidence in the work that the government does?

No

Do you have confidence that the government can improve the air quality?

Depends who is running the government

APPENDIX C - THE SMART SIGN, OPERATIONAL TEST & COMPONENTS

So, you like the sign?

Yes. I liked it. I thought it was good - I think there should be more

Do you think anybody is going to do anything as a result of the sign?

I would say yes. they would, if they could - if it was somebody who had the financial ability to get a tune-up on their car and they saw they were getting a poor reading they would do it, but I think people who are driving a bomber don't have the money anyway aren't going to do anything about it - they're going to say oh shoot I really am puffing out some smoke, oh well- but I think you could possibly get some positive results from it - especially if you sent them a card with their emissions

What do you think about the brochure?

Cute - that's a cute little brochure - I think it is clear enough - well worded

Would you have liked to have seen the brochure before going by the sign?

Well, if you went by the sign and at the next light there were little things where you could pick one up it would have been interesting - or if you went through the sign and this appeared in your mail with your readout so that you knew because yesterday when we went through, it was a real bright day, you almost couldn't read it - it would have been interesting to get this in the mail after I had been tested

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, I agree - because you get better gas mileage and you get longer wear and tear on your tires - when my gas mileage starts going down I get it tuned up

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Definitely agree - I took a class in environmental science and I agree that it just does

How much would you be willing to pay to fix your car so that it falls into the good category?

\$150 dollars

What is the air pollution problem?

Coal burning power plants and vehicles, but I think that the certain coals that they burn could be different

What do you believe causes the brown cloud?

Cars and the inversion

What do you suggest we do about the problem?

The light rail system - I'm from New England and so for me to live in Broomfield and not have access to a train that can take me to downtown is stupid - they should have a train that went from Boulder to Broomfield to downtown and all the way down to Littleton I think people would use it - especially if it hit Mile High and it hit Coors

around it - even with the Clean Air Act and all of the other stuff that goes along with it - for two years, if you have a vehicle it passes inspection and the next day it is in poor condition, that person is going to drive that vehicle without doing anything about it

What do you think is the best way of solving this problem?

We have a very poor mass transit system here - to give you an example - where I live out in Arvada, the bus system for me, I have to actually get in my vehicle, and travel three or four miles to a park-n-ride, get on the bus and it drops me off six blocks from my office, I have to walk over here and it's only at certain times, and if I miss those buses, then I have to go to another park-n-ride in Broomfield, and I live in Arvada - so it's not accessible - it's not available - they just haven't made it economically sound for people - it's becoming more cumbersome - once they can take a look at that - here you got an airport that sits out on the plains and it's just right for some kind of rail system to transport people, either from downtown, or the old Stapleton, at a high speed, that would eliminate an unbelievable amount of traffic out there, that I would be willing, and most people, I think would be willing to take - but, it still sits there - you know, we fill the potholes in our highways, but we really haven't tackled the problem, mass transit - we're back in the fifties - we've got a bus system - in about forty years - we add a light rail that's four or five miles long and that's it - that's the extent of the improvement in Colorado

If the bus was accessible would you pay \$ 10 dollars for a monthly bus pass?

I'd pay more than that - twenty-five dollars a month

If it was possible that the RTD could be subsidized through a gas tax would you be more willing to use the system?

Yes, I believe it would be used more, certainly not a personal level - need for a car for work

If the light rail was accessible would you pay \$ 10 dollars for a monthly light rail pass?

Twenty-five dollars

What do you believe causes the brown cloud?

The majority of it is from motor vehicles and the weather conditions here in Colorado - the inversion

Probe - sand and chemicals that are used on the highways

Would you be willing to participate in an emission based registration fee program?

Conceptually, it doesn't sound bad, and basically what it is saying is, let's tax the people that are causing the problem - in reality, people are going to question the readings

In general, do you have confidence in the work that the government does?

Since I'm a government worker, I would hope so - I'd say there's trust and distrust depending on what level and where you go with it - I think there's a lot of trust that there is police work being done on industrial pollutants, but there's a lot of distrust when it gets down to the local level because you just see too many things happening bouncing back and forth

Case #16

Good

What was your first impression of the sign?

I thought it was interesting, it caught my attention

What do you remember about it, specifically?

I drive by there all the time so I remember it really well - It has the little smiling car on it and when I drive by it says. good and then it says, saving you money, and the other thing I wonder is if it is saying good about me or the person in front of me - I go by about once a week - and then I've noticed the little sign that's behind it, it has the question mark if you have questions about the car that you can call that phone number

How many times have you been by the sign?

Probably more than twenty times

Did you understand it at first?

Yes, I understood that there was something back there behind me that was looking at the emissions - I figured that out

Do you think the sign is pretty easy to see?

Yes

Would you have liked an earlier sign saying what was coming up?

Some people might want that, but that wouldn't be something that I really needed - I think in that particular spot it might even be a distraction just because you're right at that point getting off I-25

Why do you think the sign is there?

To make people aware that the exhaust that's coming out has more toxins in it than it should - I think the whole point of saying it's saving you money is letting people know you've had your oil changed so actually your car's health is going to be better and have fewer repairs and it's always said good for my car so my assumption would be that if it says bad or not so good, then it would say costing you money - so my assumption would be that it's to show people that they need to get their car taken care of - I think the whole point of saying saving you money or costing you money would be because that's probably going to be more of an incentive to the average person who doesn't care about the environment

So, do you like the sign, you think it's good or helpful?

I do, yes

Case #20

Good

What was your first impression of the sign?

I was surprised - I was also somewhat disillusioned in the sense that I thought, oh yeah, right, it's really going to pick up a reading on my vehicle because there was like three cars within maybe thirty, forty feet of each other, one after another - I was just questioning its accuracy

What do you remember specifically about the sign?

The immediacy of it - you see the weird little contraption that sits over on the right hand side and you wonder what is that and then your eyes are immediately drawn to the sign and then it gave me a reading of good and I thought, yeah, right - how accurate it was I don't know

How many times have you been by there?

Probably ten times

Did you understand it at first that it was measuring vehicle emissions?

No, I had no concept whatsoever what it was - no idea

Did you notice the message at the bottom of the sign?

Probe - yes

Did you notice a second sign?

Not until it was brought to my attention - when the lady who called me who did the initial telephone interview asked me if I had seen that second sign - it wasn't until I went through that area again, that offramp, that I noticed the sign - it was not immediate to me the first time

What was it like seeing the sign?

The big sign itself was easy to see - I had no problem reading it - especially, you have to slow down, especially on that offramp - it certainly gives you ample time to read it

Would you have liked an earlier sign saying your car emissions are going to be read up ahead?

I don't know if it's necessary

Why do think the sign is there?

Probably a couple of reasons - one of them is that Denver has had some major pollution problems - it's also tied into some federal dollars, some highway dollars, and some other kind of stuff - we have a unique situation also in Colorado - that may or may not be true in other cities - and that is the inversion with the mountains and the type of weather that we have here in Colorado - in some cases is more conducive to a pollution problem - I think it's a very good idea - it's certainly an informative thing - whether or not most people are consciences enough to do something about it is questionable - if it says bad, I might say, ok, fine, I just won't go this way anymore

Would you be willing to participate in a program for an emission based registration fee program?

Yes, I think that something like that would be really interesting - I think there should be some type of a reward for people who are keeping their car in good shape - yes, I'd generally be in favor of something like that

In general, do you have confidence in the work that the government does?

Yes, in general

Do you have confidence that the government can improve the air quality?

I think through policies - through enforcing those you can - forcing economically the American public to give up their automobile - I guess it's just a cultural thing, but in all the cities I've lived in mass transit has not been a big thing

Case#19
Good/Fair

What was your first impression of the sign?
I thought it was a good idea

What do you remember about it?
I remember seeing the sign and it said good, you're saving money - so I wondered how in the world they were able to do that

How many times have you been by there?
Probably a dozen times

Did you understand it at first?
Yes

Did you notice a second sign?
No

Did you think it was pretty easy to see?
Yes - I think it works real fine - the appearance

Would you have liked an earlier sign saying what was coming up?
I don't think I would have even recognized it

Why do think the sign is there?
I thought it was a way of testing what was going on in the way of pollution, emissions, and so forth

You like the sign, you think it's good, helpful?
Yes - it is good, helpful

Do you think anyone is going to do anything as a result of the sign?
I don't think at the time they would - the next inspection that they would have - they would probably do something then - I don't think people are going to get their car taken care of just because they see something going on with the sign - there might be some consciences folks that would do it

What do you think about the brochure?
Nice brochure

Would you have liked to have seen this before you went by the sign?
It would probably have helped a little bit

What do you think about the brochure?

Likes it

Would you have liked to have seen the brochure before driving past the sign?

No not really. thought it would cause a lot of traffic if people picked one up

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, oil changes will keep the internal combustion engine running

How much would you be willing to pay to fix your car so that it falls into the good category?

Whatever it would take - wouldn't pay more than \$2000 dollars since that is more than the worth of the car

What is the air pollution problem?

Wood burning and vehicle emissions

What do you believe causes the brown cloud?

Also, wood burning and vehicle emissions

What do you suggest we do about the problem?

What we're doing now

Would you be willing to participate in an emission based registration fee program?

Yes, would be in favor

In general, do you have confidence in the work that the government does?

Yes, in general

Do you have confidence that the government can improve the air quality?

For the most part

(Conversation) Would like to see the sign stay up



Figure 3. Photography of the Smart Sign as deployed. The top photo displays the GOOD message, the middle photo the FAIR message and the bottom photo the POOR message.

Would you have liked to have seen this before you went by the sign?
Not really

Do you agree or disagree that keeping your car well-maintained actually saves money?
Yes. air filters clean up pollution and spark plugs give you power - some people let things go and they shouldn't - some people do too much maintenance on their cars

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?
Yes (same reasons as above)

How much would you be willing to pay to fix your car so that it falls into the good category?
If the technology was reliable I would spend \$200 - \$300 dollars - if I owned a nicer car I would spend \$400 - \$500 dollars

in your opinion, what is the air pollution problem?
Cars - too many people - it's just getting to a saturation point

What do you believe causes the brown cloud?
It's the cars - I know from what I've heard or read that around 85% is from just personal vehicles and another 20% is just from industry or trucks - lawnmowers and stuff is like 10%

What do you think we should do about the problem?
Bike - get a good public transportation system - it's a tough problem

Probe - light rail

If the light rail was accessible would you pay \$10 dollars for a monthly light rail pass?
\$30 dollars - light rail is better than the bus because of all the stops with the bus - would take 15 minutes with the light rail and 40 minutes with the bus and that just turns me off

Would you be willing to participate in a program for an emission based registration fee program?
The problem would lie with the people who have bad cars who don't have the money - or if a company had a fleet of cars and had to pay, they wouldn't like that - money talks - it would probably work though, the majority of the people would probably want something like that - because most cars do pass emissions - and it would make them aware - I think awareness of pollution and the environment will probably help people, even recycling, to be more aware

In general. do you have confidence in the work that the government does?
Yes, in general

Do you have confidence that the government can improve the air quality?
Yes, they can try - they can pass laws and make people drive 4 cylinder cars - they really could and people don't need that - stricter on auto makers - that might be the first place to start - but they could have an impact - people don't need these 8 cylinder cars - they really don't. but it's America and they would fight for their rights to a Cadillac or whatever they want

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cause, Real time information regarding emissions is of interest more than once every two years.

The idea of a variable message sign, as a public service, is viewed positively. The information provided in these focus groups is valuable in determining the format and content of the sign. The key informational aspects of the sign will be:

YOUR EMISSION IS

GOOD - FAIR - POOR

COSTING/SAVING YOU MONEY

HOT LINE PHONE NUMBER

(# on a second sign)

The graphics will use the car and the emission plume coming from the tailpipe. Color graphics will highlight the plume and reading.

current vehicle fleet. Three emission categories necessitated a three color system that would be visible in bright sunshine. The multi-colored sign is organized with red (> 4.5% CO, a gross polluting vehicle), amber (1.3 - 4.5% CO, a marginal emitter) and green (< 1.3% CO, the low emitting vehicle). Amber and red LED's have been available for some time in high intensity versions suitable for daytime applications. The Smart Sign is one of the first uses of a new high intensity green LED technology.

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Focus Groups

The partners conducted three focus groups in an effort to design and implement the plans for a the variable message sign and the overall design of the operational test. We sought input on key issues such the type of information to convey, the number of signs to use, their size, their motivational and attention getting properties and their information processing and learning components.

The first group was composed of a group of experts from various fields including the business, communications, graphic design, marketing/advertising, transportation and academia. This group was assembled to help narrow the field of topics to be discussed in our general public focus groups. The discussion that followed centered on three categories the group felt important, external factors affecting the effectiveness of the sign, methods and communications.

SIGNAGE PROTOCOL

CDOT/DU

I. MODERATOR INTRODUCTION

A. Purpose of Meeting

1. Focus is on air pollution
2. How to get people information regarding the status of their car's emission

B. Focus Group Explanation

1. Conversation
2. Between people with common interests
3. Whose thoughts and ideas reflect those of many other people

C. Why you?

1. You drive
2. Breathe Denver's Air
3. Representation
4. Random Calls

D. Ground Rules

1. Be honest -- you won't hurt my feelings or the people who hired me.

SMART SIGN OPERATIONAL TEST AND COMPONENTS

Location

The Smart Sign operational test is located in Denver Colorado at Interstate 25 exit number I12.4. This is a single-lane uphill (4% grade) off-ramp which connects to southbound Speer Blvd. This ramp is located in the central Platte valley near downtown Denver, and Speer Blvd. is a major arterial feed for downtown traffic. This central location experiences some of the heaviest traffic in all of the Rocky Mountain region.

This site was chosen for several important reasons. It has one of the longest monitoring histories for remote sensing measurements dating back to 1989 (Bishop and Stedman, 1990). In addition the experience at this location ensures a near ideal location for conducting tailpipe emission measurements with an RSD as the successful measurement rate at this location consistently exceeds 98% for ideal conditions. Two final pluses are the close proximity to the University of Denver's campus and the fact that electrical power has already been installed on both sides of the on-ramp. Both of these aspects help to maximize the data collected and minimize the costs associated with performing the demonstration. In addition the Denver area weather includes all major types which will need to be evaluated for determining the test's suitability for other national locations.

The Remote Sensing Device

With support from the Colorado Office of Energy Conservation in 1987, the University of Denver developed an infra-red (IR) remote monitoring system for vehicular CO exhaust emissions (Bishop et al, 1989). Significant fuel economy improvements result if rich-burning (high CO and HC emissions) or misfiring (high HC emissions) vehicles are tuned to a more stoichiometric and more efficient air/fuel (A/F) ratio. The basic instrument measures the carbon monoxide to carbon dioxide ratio (CO/CO₂) and the hydrocarbon to carbon dioxide ratio (HC/CO₂) in the exhaust of any vehicle passing through an IR light beam which is transmitted across a single lane of roadway. Figure 1 shows a schematic diagram of the instrument setup.

The RSD was designed to emulate the results one would see using a conventional non-dispersive infra-red (NDIR) exhaust gas analyzer. Thus, it is also based on NDIR principles. An IR source sends a horizontal beam of radiation across a single traffic lane, approximately 10 inches above the road surface. This beam is directed into the detector on the opposite side and divided between four individual detectors; CO, CO₂, HC, and reference. An optical filter that transmits IR light of a wavelength known to be uniquely absorbed by the molecule of interest is placed in front of each detector, determining its specificity. Reduction in the signal caused by absorption of light by the molecules of interest is translated into the individual tailpipe concentrations.

An RSD can measure the CO and HC emissions in all vehicles, including gasoline and diesel-

B. What are the primary causes of air pollution?

(Probe: Which are largest contributors)

- Exhaust from vehicles used to drive to work
- Woodburning stoves/fireplaces
- industry
- Diesel vehicles
- Untuned cars
- Geography/temperature inversions
- Dust, particles from the streets

C. Progress?

1. is air pollution in Denver and Colorado getting better or worse?
2. For what types of pollution?
3. Reasons?

D. What are some current, and maybe future, solutions you believe are, or will, do the most to solve our air pollution problems? Why?

- Technology that reduces auto pollution
- More efficient street sweeping
- Slowdown growth
- Better enforcement of mandatory woodburning bans
- Tickets/fines for excessive polluting cars
- Buy up old cars
- Increased use of alternate fuels (CNG, propane)

APPENDIX C - THE SMART SIGN, OPERATIONAL TEST & COMPONENTS

- D. Why did they change from the old program?
- E. Attitude toward the new program
 - 1. What are the good points? .
 - a. More stringent
 - b. Reduce fraud
 - c. More consistent
 - d. Every 2 years
 - e. Compliance
 - 2. What are the problems?
 - a. Everyone pays when only a few cars are bad
 - b. Reliability
 - c. Convenience
 - d. Costs
 - 3. Overall attitude
 - a. Why?
 - b. What should be done to improve it?

IV. INFRARED SENSING

- A. Are you familiar with any alternatives being proposed to IM-240?
 - 1. What are they?
 - 2. What do you know about them?
 - 3. What are your general impressions?

around it - even with the Clean Air Act and all of the other stuff that goes along with it - for two years, if you have a vehicle it passes inspection and the next day it is in poor condition, that person is going to drive that vehicle without doing anything about it

What do you think is the best way of solving this problem?

We have a very poor mass transit system here - to give you an example - where I live out in Arvada, the bus system for me, I have to actually get in my vehicle, and travel three or four miles to a park-n-ride, get on the bus and it drops me off six blocks from my office, I have to walk over here and it's only at certain times, and if I miss those buses, then I have to go to another park-n-ride in Broomfield, and I live in Arvada - so it's not accessible - it's not available - they just haven't made it economically sound for people - it's becoming more cumbersome - once they can take a look at that - here you got an airport that sits out on the plains and it's just right for some kind of rail system to transport people, either from downtown, or the old Stapleton, at a high speed, that would eliminate an unbelievable amount of traffic out there, that I would be willing, and most people, I think would be willing to take - but, it still sits there - you know, we fill the potholes in our highways, but we really haven't tackled the problem, mass transit - we're back in the fifties - we've got a bus system - in about forty years - we add a light rail that's four or five miles long and that's it - that's the extent of the improvement in Colorado

If the bus was accessible would you pay \$10 dollars for a monthly bus pass?

I'd pay more than that - twenty-five dollars a month

If it was possible that the RTD could be subsidized through a gas tax would you be more willing to use the system?

Yes, I believe it would be used more, certainly not a personal level - need for a car for work

If the light rail was accessible would you pay \$ 10 dollars for a monthly light rail pass?

Twenty-five dollars

What do you believe causes the brown cloud?

The majority of it is from motor vehicles and the weather conditions here in Colorado - the inversion

Probe - sand and chemicals that are used on the highways

Would you be willing to participate in an emission based registration fee program?

Conceptually, it doesn't sound bad, and basically what it is saying is, let's tax the people that are causing the problem - in reality, people are going to question the readings

In general, do you have confidence in the work that the government does?

Since I'm a government worker, I would hope so - I'd say there's trust and distrust depending on what level and where you go with it - I think there's a lot of trust that there is police work being done on industrial pollutants, but there's a lot of distrust when it gets down to the local level because you just see too many things happening bouncing back and forth

EXPLAIN REMOTE SENSING STUDY

- Cooperative effort (DU, CDOT, CSU, Conoco)
 - Purpose is to provide real-time vehicle emission information to the public
 - Program Components
 - Variable Message Sign
 - Short band radio
 - Hotline
 - Brochures
 - Implementation
 - VMS on the off-ramp of I-25
 - Single lane
 - VMS will convey CO reading to the driver as he/she drives past (the infrared sensing device having “read” the emissions earlier along the off-ramp)
 - The radio, hotline, and brochures will provide supporting educational information to the sign
 - Any action taken on the part of drivers will be purely voluntary
 - Multiple exposures over time
- C. Reactions to Sign Information
1. Assumptions
 - a. Ramp flow pattern O.K.
 - b. Readability in terms of size, etc.

Case #20

Good

What was your first impression of the sign?

I was surprised - I was also somewhat disillusioned in the sense that I thought, oh yeah, right, it's really going to pick up a reading on my vehicle because there was like three cars within maybe thirty, forty feet of each other, one after another - I was just questioning its accuracy

What do you remember specifically about the sign?

The immediacy of it - you see the weird little contraption that sits over on the right hand side and you wonder what is that and then your eyes are immediately drawn to the sign and then it gave me a reading of good and I thought, yeah, right - how accurate it was I don't know

How many times have you been by there?

Probably ten times

Did you understand it at first that it was measuring vehicle emissions?

No, I had no concept whatsoever what it was - no idea

Did you notice the message at the bottom of the sign?

Probe - yes

Did you notice a second sign?

Not until it was brought to my attention - when the lady who called me who did the initial telephone interview asked me if I had seen that second sign - it wasn't until I went through that area again, that offramp that I noticed the sign - it was not immediate to me the first time

What was it like seeing the sign?

The big sign itself was easy to see - I had no problem reading it - especially, you have to slow down, especially on that offramp - it certainly gives you ample time to read it

Would you have liked an earlier sign saying your car emissions are going to be read up ahead?

I don't know if it's necessary

Why do think the sign is there?

Probably a couple of reasons - one of them is that Denver has had some major pollution problems - it's also tied into some federal dollars, some highway dollars, and some other kind of stuff - we have a unique situation also in Colorado - that may or may not be true in other cities - and that is the inversion with the mountains and the type of weather that we have here in Colorado - in some cases is more conducive to a pollution problem - I think it's a very good idea - it's certainly an informative thing - whether or not most people are consciences enough to do something about it is questionable - if it says bad, I might say, ok, fine, I just won't go this way anymore

Q: Information

Easy to read

Understandable

Q Good - Fair - Poor vs. Low - Med. - High

Good vs. efficient

(Probe: Fair category)

(4)

Q: Car face

Is humor good?

Does it come across

Test 3: Educational Message

---> Show S4 - S5

Social vs. Economic message

Test 4: Overall Impression

---> Show S6

Happy Face/Costing you Money \$\$\$

*** Will people take action? Why?

Q: How important is it to know sponsors?

Language problems for some

Relation to emission test (Im - 240)

inconsistency of reading

Importance of conveying when the sign is off/on

Colors

Call to action #

Case #I9

Good/Fair

what was your first impression of the sign?

I thought it was a good idea

What do you remember about it?

I remember seeing the sign and it said good, you're saving money - so I wondered how in the world they were able to do that

How many times have you been by there?

Probably a dozen times

Did you understand it at first?

Yes

Did you notice a second sign?

No

Did you think it was pretty easy to see?

Yes - I think it works real fine - the appearance

Would you have liked an earlier sign saying what was coming up?

I don't think I would have even recognized it

Why do think the sign is there?

I thought it was a way of testing what was going on in the way of pollution, emissions, and so forth

You like the sign, you think it's good, helpful?

Yes - it is good, helpful

Do you think anyone is going to do anything as a result of the sign?

I don't think at the time they would - the next inspection that they would have - they would probably do something then - I don't think people are going to get their car taken care of just because they see something going on with the sign - there might be some consciences folks that would do it

What do you think about the brochure?

Nice brochure

Would you have liked to have seen this before you went by the sign?

It would probably have helped a little bit

APPENDIX B

VMS Alternatives

Do you agree or disagree that keeping your car well-maintained actually saves money?

I agree - well it's like any other piece of equipment - if it's kept well, it's going to service you well - if it's in top tuned condition it's going to be a good tool for you - whether it's an automobile or a drill

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Yes. I do agree - because that's the reason they're building the cars the way they are is to keep the pollution down and if you don't keep it tuned up then it's not going to keep the pollution away

How much would you be willing to pay to fix your car so that it falls into the good category?

Well I'd pay whatever I'd have to pay to get it fixed because if it's emitting pollution it's not running well and if it's not running well you're not getting the best service out of the vehicle

What is the air pollution problem, in your opinion?

Vehicles that are using carbon based fuels

What do you believe causes the brown cloud?

Vehicles - they used to say it was the Cherokee Plant out there in public service - they contribute to it, but not when a whole brown cloud is going all around the valley

What do you think is the best way to go about solving the problem?

I think there needs to be more public transportation - there needs to be more education - and when I say public transportation, it's got to be convenient

If the bus was accessible would you pay \$10 dollars for a monthly bus pass?

\$20 dollars

If it was possible that the RTD could be subsidized through a gas tax would you be more willing to use the system?

I'd do that

If the light rail was accessible would you pay \$ 10 dollars for a monthly light rail pass?

I would take the bus to the light rail

Would you be willing to participate in an emission based registration fee program?

I don't know because I'm only paying \$50 bucks a year now because I have an older vehicle, so I don't know about that one - my answer would be no

In general, do you have confidence in the work that the government does?

No

Do you have confidence that the government can improve the air quality?

I don't think so - because we've been doing this for ten years now, maybe longer than that, and we still have the brown cloud

Test 5: Awareness Sign Alternatives

→ Show each sign

Reactions to: Format

Wording

→ How To Keep The Sign Fresh!

D. Final Advice

1. How do we make the sign better?
2. General advice on how we can really reduce air pollution

→ Draw your sign

THANK YOU!

Do you think anyone is going to do anything as a result of seeing the sign?

No - what they will probably do is wait until their inspection is due and if they don't pass they'll take their chances - and if they don't pass the inspection then they'll do something about it, but I don't think you're gonna find too many people being proactive and saying, oh man, I better go spend some money and get my car cleaned up - I don't think you'll find that at all

What do you think about the brochure?

It's very informative - had I have had something like this before it would have made me aware

Would you have liked to have seen the brochure before going past the sign?

Oh yes, it would have been very informative - it would have told me what the ratings are and what it was actually doing

Do you agree or disagree that keeping your car well-maintained actually saves money?

Oh, most definitely - to give an example - I just sold a car that had 135,000 miles on it, with oil changes every three months - corrective type of stuff done and something like that in one way saved me a heck of a lot of money just to keep my car - oil changes at every 3,000 miles and tune-ups really increases my gas mileage with both of my vehicles - I keep them well-maintained basically because I don't want to buy another car - you know and I can keep them a long time

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Oh, most definitely - I think it's not only visual - I have some major problems with some of the pollution situations around here - it's like the burning days on fireplaces - that that's a major contributor to air pollution in Denver - what's really surprising is that for many many months we don't have burning but we still have pollution, yet I have two fireplaces that I went ahead and converted to gas, but it just seemed to me that the volume of those fireplaces certainly doesn't contribute to the volume of pollution that is from the motor vehicles - and yet I think it's something that they can measure and tell the federal government, well, this is what we're doing and now we have control days you can't burn, the pollution is such and such, but we still have major pollution regardless of whether you bum fireboxes or not

How much would you be willing to pay to fix your car so that it falls into the good category?

I have yet to find a mechanic that knows how to write a bill under \$100 dollars - no matter what I go in for, it's a hundred bucks plus - so I would say that's probably a good area - about a hundred bucks

What is the air pollution problem, do you think?

I would say that on the average, if you just leveled out the mountains, Denver would not have a pollution problem based on the amount of vehicles that we have here, but when you combine that with our weather conditions and the inversion problems we have here the smallest amounts of pollution basically sits instead of blowing out where it belongs out on the plains - it's just a unique situation here - it is a combined thing - you're never going to get around the inversion problems and the weather conditions here in Colorado - so I do believe other steps have to be taken, but Denver's growing and Colorado is growing, so I think it's inevitable - I don't know how you're going to get

2. Question -- What should the sign look like?

We want to review with you several options and get your **opinion**.

3. Key Questions

- a. Overall impressions
 - graphics
 - messages
- b. Amount
- c. Type of information
- d. What's missing
- e. How to improve

Test 1: Ability to Read/Comprehend

→ Show S₁ , S₂ S₃ in 2 second intervals

Q after each showing - Recall/initial impressions

→ Repeat S₁ , S₂, S₃

Test 2: Sign Impressions

→ Show S₁ - S₂ - S₃ more slowly

a: What is different? Reading car face

→ Show S₄

a: Overall impressions

Likes

Dislikes

Confusions

Do you believe the government can improve the air quality?

No - I shouldn't say totally no, because I think they already have, but I think it becomes more of a self-consciousness - if I want to do it - I think it starts at that grass root level, and there has to be that kind of consciousness and it just escalates all the way up to the top

B. Infrared Sensing -- Don Steadman

1. Awareness? (Probe: How found out)
2. Knowledge regarding how it works
 - a. Remote sensing
 - b. Determines car pollution by measuring emissions from your tailpipe as you drive by
 - c. Tested in multiple countries and states
3. Attitude
 - a. What do you see as positive aspects?
 - b. Do you see any negatives?
4. Compare to IM-240 system

v. AIR POLLUTION INFORMATION

A. Current Awareness

1. How many are aware of the status of their car/s emissions?
(Probe: What they know, how they found out.)
2. How do you currently get information?
3. Would it be helpful if a service was provided to inform you of your car's emissions? (Probe: Why or why not?)

B. How might you use such information? (n.b., the voluntary nature of information and action)

1. Repairs
2. Check-up

- More responsibility on business
- Better/more public transportation
- Better/easier testing programs

III. EMISSIONS TESTING

A. How many are familiar with Colorado's new Emissions Test Program?
(IM240)

1. Experience
2. Read about it

B. What are your impressions/experiences?

1. EPA and Federal Clean Air Act
2. Envirotest Contract
3. Maine and other States' experiences
4. Reliability of treadmill tests
5. Inconvenience -- test centers
waiting time
6. Cost of test and maintenance -- \$80-\$125
7. Hard on your car
8. Initially relaxed standards

C. What types of emissions are covered?

- Carbon monoxide (CO)
- Hydrocarbons (HC)
- Nitrogen Oxide (NO_x)

CO and HC Remote Sensing.

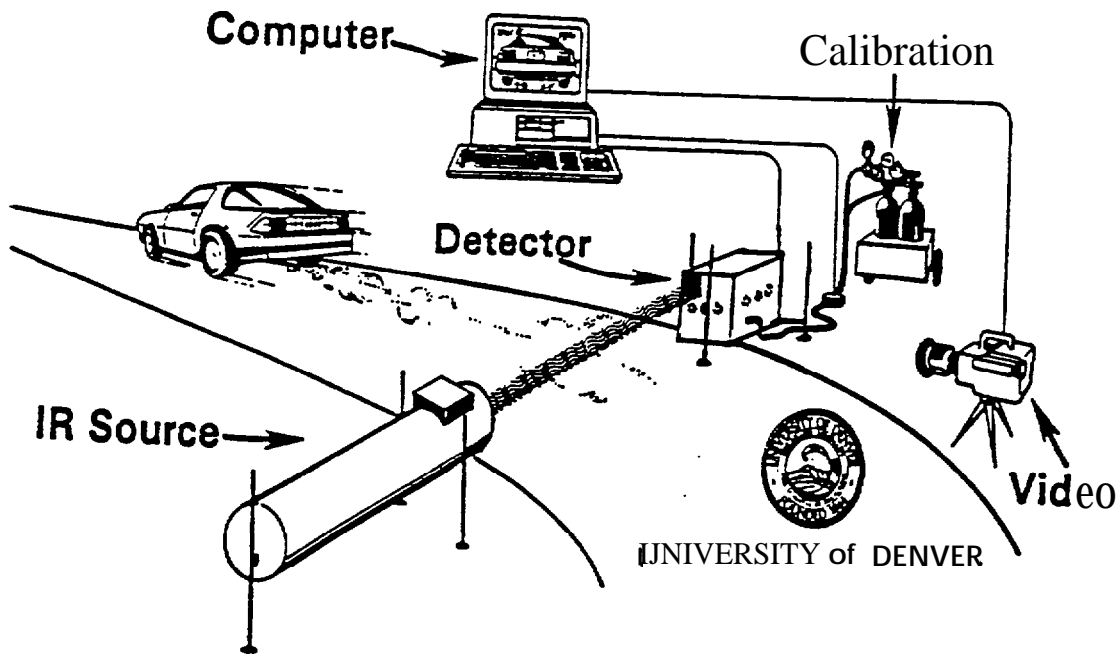


Figure 1. A schematic diagram of the University of Denver on-road emissions monitor mounted above ground. It is capable of monitoring emissions at vehicle speeds between 2.5 and 150 mph in under one second per vehicle.

powered vehicles, as long as the exhaust plume exits the vehicle within a few feet of the ground. The instrument is not limited to ground based sources and can be elevated to sense exhaust emissions which exit from the tops of vehicles like heavy-duty diesels and has been demonstrated to give good agreement with other methods (Bishop et al, 1994). The CO/CO₂ and HC/CO₂ ratios can be determined independent of wind, temperature, and turbulence in 0.9 seconds per passing car. It is effective at measuring vehicles traveling between 2.5 and 150 mph. They have been shown to give correct readings for CO and HC by means of double-blind studies of vehicles both on the road and on dynamometers (Lawson et al. 1990; Stedman and Bishop, 1991; Ashbaugh et al, 1992).

Variable Message Sign

The operational test combines a remote sensor to determine vehicle exhaust emissions with a custom variable message sign to display emission levels to the driver.

The variable message sign was designed and constructed in cooperation with Skyline Products Inc of Colorado Springs, CO. It incorporated many of the advanced highway sign technologies which are currently being used around the country and took advantage one new product. Research suggested that three emission categories were needed to fully cover the

2. No right or wrong answers
3. Tape recorded, two-way mirror
4. Talk one at a time
5. Run about 1 1/2 - 2 hours with a break in the middle

10
E. Introduce Table

II. AIR POLLUTION PERCEPTIONS

A. How serious is the problem?

1. Level -- Global, National, State, Local
2. Why is it serious?
 - a. Health (Probe: types of problems)
 - b. Visual/aesthetic
 - c. Economic
 - Personal
 - taxes
 - inefficient cars
 - fuel costs
 - emissions testing costs
 - Regional
 - economic development
 - federal mandates
 - social costs

External factors that the group felt were important included the potential for a driver being shown the wrong emissions reading due to variance in the ramp speed of the vehicles. Drivers not having enough time to read and process the information from the sign. The natural emissions variability and thus inconsistent readings of some vehicles. The language problems of some population segments and the potential for inconsistent messages between the sign and other vehicle inspection programs. Many of these concerns were viewed as largely uncontrollable from the standpoint of the operational test but important to consider in advance to assure the credibility of the information.

Concerns about the methods and design of the study involved the question of generalizability of the data. Would the public perceive the license plate reader as an invasion of privacy? How would we involve the media? A concern was expressed that we needed to downplay the government role.

All of these participants felt that the communications aspects of the program and the design of the sign to be the most important. They felt the sign should use color for attention getting purposes and to assist in conveying information. That some type of scale with pictures were preferred over words and numbers. The scale used needed to have an understandable rating system and we needed to keep the sign simple and humorous.

This information was collected and used to refine the questions and issues which were next submitted to two focus groups from the general public. In February of 1995 two groups (one men and one women) of randomly selected drivers were assembled for a two hour discussion of general air quality concerns and their perceptions about the Smart Sign. Graphic designs of potential sign concepts prepared by Conoco, were viewed by each group and comments were taken. Figure 2 shows a graphic which included all of the various test elements that we examined in the groups.

Conclusions of the groups were that the idea of a variable message sign offered as a public service was viewed very favorably. This favorable view grew out of the groups interest in improving Denver air quality and the idea that current access to vehicle emissions information was too infrequent. They encouraged us to make the sign fun emphasizing a lighter side encouragement as opposed to a "big brother" type of big stick approach. The groups also wanted the sign to stay away from numbers in favor of Good/Fair/Poor and to use monetary incentives as opposed to environmental concerns. The women were especially emphatic about money being a stronger motivational message.

Key Features

The Smart Sign design that emerged from the focus groups was one which involved a multi-colored variable message sign which would could provide emissions information to drivers on several different levels. It was widely acknowledged that all of the information on the sign would be difficult to comprehend in a single exposure and our exposure experiments show that different people were drawn to different elements in the sign. The sign design team took

APPENDIX A

VMS Focus Group Protocol

The sign was constructed with an all aluminum cabinet and sign face. For service the front face of the sign could be raised and lowered via a screw drive located on the bottom edge of the cabinet. To improve the nighttime viewing the declarative statement and the cartoon car would be back lit using standard fluorescent bulbs. This was accomplished by machining the outline of the characters and the car into the aluminum face plate. To improve the nighttime viewing of the remaining sign features, diamond grade Scotchbrite reflective sheeting was used for the white piume outline and the blue background. All of the LED segments were masked against a black background except for the radiator area of the cartoon car. This area was masked in a grayish white to give it a more car-like appearance. Finally the entire face was covered with a single sheet of polycarbonate sheeting to prevent damage to the sign facing from vandalism. The final product is shown in Figure 3.

SITE CONSTRUCTION

The site selected is located in the southwest quadrant of the interchange between southbound Interstate 25 and eastbound Speer Blvd (see Figure 4). The site had previously installed electrical hook-ups on both sides of the off-ramp. Site surveys were conducted by Merrick Engineers & Architects and utility permits were obtained from the Colorado Department of Transportation.

Additional site preparation was needed to route the electricity to the five equipment locations on the outer edge of the ramp and to a single installation on the inside edge of the ramp. A phone line needed to be installed. Underground bunkers for the detector and the source needed to be constructed and concrete footings were needed for the VMS sign mounts.

Site preparation began in October 1995 and continued through February 1996. The two companies utilized for site preparation included Utilix and W. L. Contractors, both of Denver. Conduit was installed from the nearest telephone pedestal located about 300 ft. west of the site. Installation of this conduit was accomplished via a directional bore. Additional trenching and conduit was laid from the location for the control cabinet to the signs location, to the remote sensor bunker, to the utility pole which would hold the license plate reader and the location of the optical sign triggering device. All conduit was installed to meet the installation requirements of the Colorado Department of Transportation. Electrical wiring and signal cables were installed in separate conduit.

Approximately 250 ft. up the off-ramp two concrete bunkers were prepared below ground level to house the detector and source units. The detector bunker was constructed using two precast concrete pipes (2.5 ft Iorg, 3 ft ID) fitted with a 3 1.5 inch diameter aluminum manhole ring and lid. The manhole ring was cemented to the top of the two precast pipes. The source bunker, located on the inside portion of the off-ramp, was fabricated at the site from concrete. This bunker is a 24 inch diameter cylinder approximately 5 feet deep with a square aluminum hatch and mounting ring. The bottom of each bunker was lined with approximately 3 inches of coarse gravel for drainage purposes.

Case #18

Good, fair, poor

What was your first impression of the sign?

I didn't know what it was at first

What do you remember about it?

Ratings - I've gotten all readings - one day it will be bad, one day it will be good - I just got emissions on my truck and it still says bad - you know the equipment is probably wrong

Did you notice the message at the bottom of the sign?

Yes, saving you money, costing you money

Did you notice a second sign?

Probe - no

Did you find it easy to see?

Yes, it's pretty easy - it's pretty obvious - I think even if it doesn't give good readings, at least it makes people aware of their emissions - just for awareness

Would you have liked an earlier sign saying what was coming up?

No, it's too busy of a corner

Why do think the sign is there?

Probably just more of awareness - to let people know that they have to watch the environment

How did you feel about seeing the sign?

I didn't think it would offend anyone if they had a bad rating - if it did it would make them feel a little guilty - maybe they'd do something about their car if it was consistently bad

Do you think anyone would do anything as a result of the sign?

Yes I think they would - it would get on their conscience and they might get their car checked out, especially someone who is not really mechanically inclined - they would feel guilty - thinking this car is really bad

Did you do anything as a result of the sign?

No - not at all

What do you think about the brochure?

These would be helpful if they really picked them up and read them - it's a good sign - it's a friendly little car - people aren't intimidated

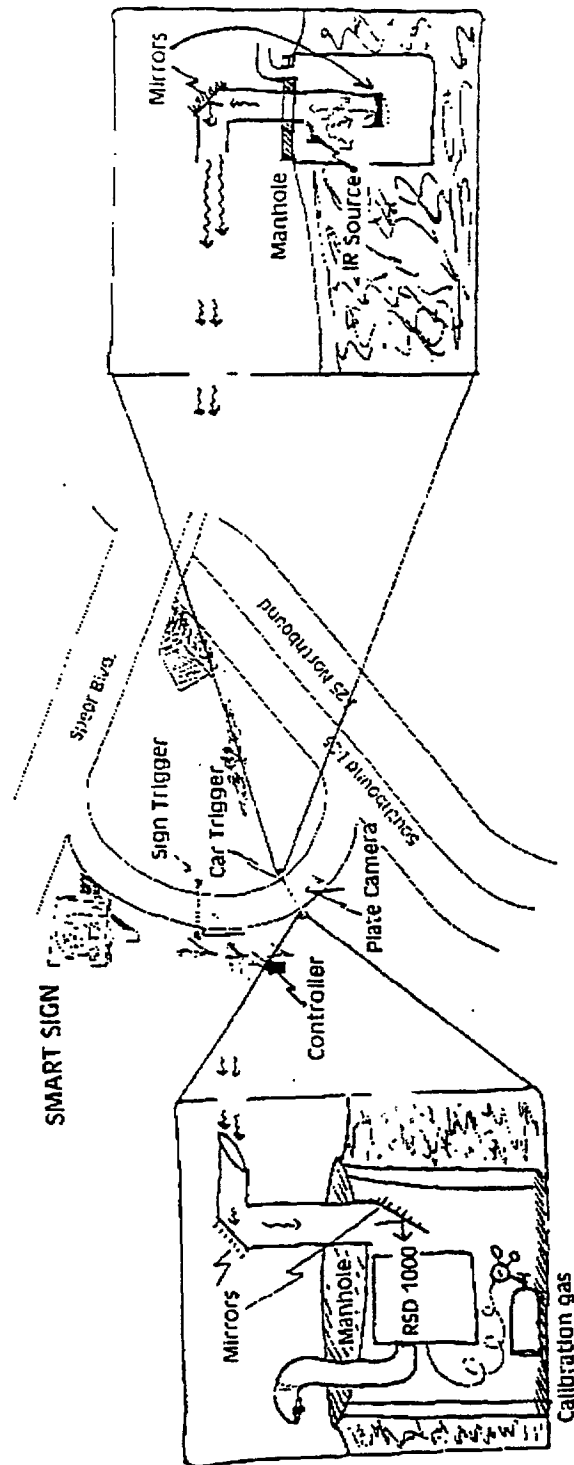


Figure 4. Artist rendering of the site layout at Speer Blvd. and Interstate 25. The enlarged views give a schematic representation of the detector and source bunkers with the optical periscopes.

Case #17

Good

What was your first impression of the sign?

Found it favorable - wife told him about it before going down there

What do you remember?

Remember the good reading and that it was green

How many times have you been by the sign?

four or five

Did you understand it at first?

Yes, because wife had informed him of it

Did you notice the message at the bottom of the sign?

No

Did you notice a second sign?

No

What was it like seeing the sign?

Easy to see

Would you have liked an earlier sign saying what was coming up?

No, probably not

Why do you think the sign is there?

Public awareness

How did you feel about seeing the sign?

Thought it was good and helpful

Do you think anyone is going to do anything as a result of the sign?

Thinks some people will do something as a result

Have you done anything as a result of the sign?

No, because he got a good reading

Did you receive a brochure?

No

Do you agree or disagree that keeping your car well-maintained actually saves money?

I agree - well it's like any other piece of equipment - if it's kept well, it's going to service you well - if it's in top tuned condition it's going to be a good tool for you - whether it's an automobile or a drill

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Yes. I do agree - because that's the reason they're building the cars the way they are is to keep the pollution down and if you don't keep it tuned up then it's not going to keep the pollution away

How much would you be willing to pay to fix your car so that it falls into the good category?

Well I'd pay whatever I'd have to pay to get it fixed because if it's emitting pollution it's not running well and if it's not running well you're not getting the best service out of the vehicle

What is the air pollution problem, in your opinion?

Vehicles that are using carbon based fuels

What do believe causes the brown cloud?

Vehicles - they used to say it was the Cherokee Plant out there in public service - they contribute to it, but not when a whole brown cloud is going all around the valley

What do you think is the best way to go about solving the problem?

I think there needs to be more public transportation - there needs to be more education - and when I say public transportation, it's got to be convenient

If the bus was accessible would you pay \$10 dollars for a monthly bus pass?

\$20 dollars

If it was possible that the RTD could be subsidized through a gas tax would you be more willing to use the system?

I'd do that

If the light rail was accessible would you pay \$10 dollars for a monthly light rail pass?

I would take the bus to the light rail

Would you be willing to participate in an emission based registration fee program?

I don't know because I'm only paying \$50 bucks a year now because I have an older vehicle, so I don't know about that one - my answer would be no

In general. do you have confidence in the work that the government does?

No

Do you have confidence that the government can improve the air quality?

I don't think so - because we've been doing this for ten years now, maybe longer than that, and we still have the brown cloud

Do you think anyone is going to do anything as a result of the sign?

I think part of the population would - I think if it popped up and said bad one time for me and costing you money I'd check out how long it's been since I had my oil changed or I'd take my car into the shop - I think for a certain population it will - I think for another part of the population they wouldn't care or they wouldn't even notice it when they drove by

What do you think about the brochure?

I think it's good - it answered a few questions that I had about it - and it has the same symbol as on the sign - it shows where it is - it gives you all the information that you need .

Would you have liked to have seen the brochure before going by the sign?

I don't think that it would have mattered - I think for the most part, the sign is kind of self-explanatory

Do you agree or disagree that keeping your car well-maintained actually saves money?

I agree because everytime I've had a car I always got the oil religiously changed and took in for regular checks it's always just had fewer problems than my other cars

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

I agree for the same reasons - I think it's just depending on how well your car is burning the gasoline and the oil and so forth - it's just going to release fewer bad things into the air

How much would you be willing to pay to fix your car so that it falls into the good category?

If it was costing me money like if I had one bad part or I needed to change the oil filter or whatever - I'd probably pay \$100 and if there was something major that needed to be repaired that was in the long run costing me money I'd probably pay more

In your opinion, what is the air pollution problem?

A lot of cars - some industry - probably cars for the most part - so many people moving at one time

What do you believe causes the brown cloud?

A lot of people - when there are this many people concentrated in one area there are going to be more pollutants created by those people

What do suggest we do about the problem?

If mass transit was something that was more realistic - you'd have to improve it - it would really help things - keeping an eye on industry and making sure that they are following all of their guidelines

If the bus was accessible would you pay \$10 dollars for a monthly bus pass?

I'd pay \$ 10 dollars, but the problem is the amount of time and the amount of stops

If the light rail was accessible would you pay \$10 dollars for a monthly light rail pass??

If there were fewer stops(thoroughfare) - I don't know if that's realistic

Do you think anyone is going to do anything as a result of seeing the sign?

No - what they will probably do is wait until their inspection is due and if they don't pass they'll take their chances - and if they don't pass the inspection then they'll do something about it, but I don't think you're gonna find too many people being proactive and saying, oh man, I better go spend *some* money and get my car cleaned up - I don't think you'll find that at all

What do you think about the brochure?

It's very informative - had I have had something like this before it would have made me aware

Would you have liked to have seen the brochure before going past the sign?

Oh yeah, it would have been very informative - it would have told me what the ratings are and what it was actually doing

Do you agree or disagree that keeping your car well-maintained actually saves money?

Oh, most definitely - to give an example - I just sold a car that had 135,000 miles on it, with oil changes every three months - corrective type of stuff done and something like that in one way saved me a heck of a lot of money just to keep my car - oil changes at every 3,000 miles and tune-ups really increases my gas mileage with both of my vehicles - I keep them well-maintained basically because I don't want to buy another car - you know and I can keep them a long time

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Oh, most definitely - I think it's not only visual - I have some major problems with some of the pollution situations around here - it's like the burning days on fireplaces - that that's a major contributor to air pollution in Denver - what's really surprising is that for many many months we don't have burning but we still have pollution, yet I have two fireplaces that I went ahead and converted to gas, but it just seemed to me that the volume of those fireplaces certainly doesn't contribute to the volume of pollution that is from the motor vehicles - and yet I think it's something that they can measure and tell the federal government, well, this is what we're doing and now we have control days you can't burn, the pollution is such and such, but we still have major pollution regardless of whether you bum fireboxes or not

How much would you be willing to pay to fix your car so that it falls into the good category?

I have yet to find a mechanic that knows how to write a bill under \$100 dollars - no matter what I go in for, it's a hundred bucks plus - so I would say that's probably a good area - about a hundred bucks

What is the air pollution problem, do you think?

I would say that on the average, if you just leveled out the mountains, Denver would not have a pollution problem based on the amount of vehicles that we have here, but when you combine that with our weather conditions and the inversion problems we have here the smallest amounts of pollution basically sits instead of blowing out where it belongs out on the plains - it's just a unique situation here - it is a combined thing - you're never going to get around the inversion problems and the weather conditions here in Colorado - so I do believe other steps have to be taken, but Denver's growing and Colorado is growing so I think it's inevitable - I don't know how you're going to get

If the light rail was accessible would you pay \$10 dollars for a monthly light rail pass?
\$10 for shopping - \$15 for work

Would you be willing to participate in a emission based registration fee program?
That would be a good idea - I'd go for that program - I think that that makes the people who are responsible - some people would try to cheat

In general, do you have confidence in the work that the government does?
Yes, in general

In general, do you have confidence that the government can improve the air quality?
Yes - if they want to they can improve it

Do you believe the government can improve the air quality?

No - I shouldn't say totally no, because I think they already have, but I think it becomes more of a self-consciousness - if I want to do it - I think it starts at that grass root level, and there has to be that kind of consciousness and it just escalates all the way up to the top

Case #15

Good

What was your first impression of the sign?

I thought it was interesting - because the guy in front of me got a very good and I only got a good- and I thought he must have a newer car

What do you specifically remember about it?

I remembered the sign with that goofy little picture of that funny little car and I remembered it flashing my rating - I thought it was interesting because I work a lot out on the roads and I see a lot of smoky cars that shouldn't be out there so I was just glad that I got a good

Did you remember another message at the bottom of the sign?

Probe - There was a little message on there - I imagine if I went through there everyday I would know what the message said

Did you understand it at first?

Yes, but I couldn't figure out how it monitored your vehicle emissions until a couple months later, or a couple weeks later I was driving by on I-25 and I looked over and I saw the monitor - I saw the gun that shoots down - probe(conversation) - that's what I saw was the license plate reader - I thought it was interesting - I knew it was measuring the exhaust

Did you notice a second sign?

Yes, that you could call if you have any questions

Would you have liked an earlier sign maybe saying what was coming up?

That would have been interesting to have a little sign that says your about to be tested for emissions or something like that - it might have been a little more helpful but based upon the expense of the sign I knew what it was right away - I knew it was testing emissions - didn't it have a little picture of smoke coming out of your car or something?

Did you find it hard to see the sign?

It was pretty clear - no it wasn't hard to see it at all

Describe your experience on the ramp?

(Probe) I never saw any of the equipment until you called me (explained before)

Why do you think the sign is there?

Probably the people who got the poor reading will go and get their oil changed or get a tune-up or something and I wonder if sometimes people are oblivious to what's coming out of their exhaust pipe - I changed my oil after I went by, but I didn't get a better rating - I got a good the other day, so

Case # 1 4
Good/Poor

What was your first impression of the sign?
I had no idea what it was

What do you remember about it?
I just remember the reading

How many times have you been by the sign?
More than twenty

Did you notice the message at the bottom of the sign?
Yes, I did notice that

Did you notice a second sign?
No - probe - oh yeah, I did, but it's quick - placement is bad just because that's when you're just starting to merge and you're looking for the car you're going to hit

Did you think it was pretty easy to see?
Lights need to be brighter

Would you have liked an earlier sign saying what was coming up?
Yes

Describe your experience on the ramp?
It took a while to figure out what it was - as soon as I figured out what it was, I thought it was great

Why do you think the sign is there?
I thought it was there because obviously somebody was doing a study

How did you feel about seeing the sign?
Thought it was good

Do you think anyone is going to do anything as a result of the sign?
I did - I worked on my car (tune-up) - but I'm conscious of it because I drive an '82 Wagoneer

What do you think about the brochure?
The car doesn't do much for me

Would you have liked to have seen it before you went by the sign?
Yes

CO and HC Remote Sensing'

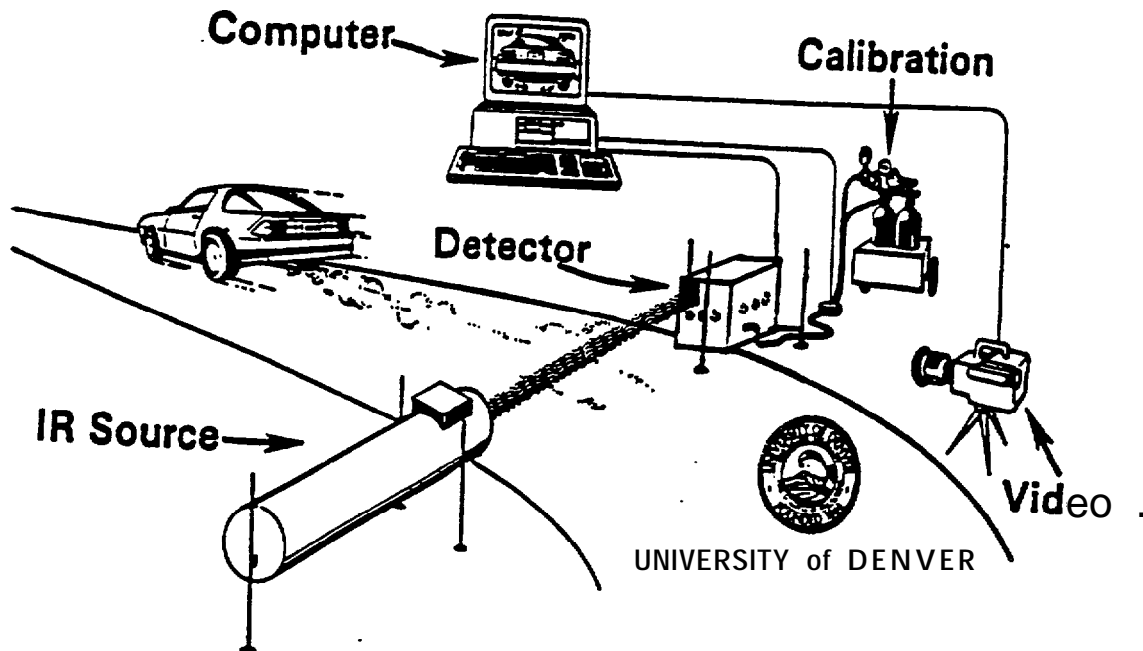


Figure 1. A Schematic diagram of the University of Denver on-road emissions monitor mounted above ground. It is capable of monitoring emissions at vehicle speeds between 2.5 and 150 mph in under one second per vehicle.

powered vehicles, as long as the exhaust plume exits the vehicle within a few feet of the ground. The instrument is not limited to ground based sources and can be elevated to sense exhaust emissions which exit from the tops of vehicles like heavy-duty diesels and has been demonstrated to give good agreement with other methods (Bishop et al, 1994). The CO/CO, and HC/CO₂ ratios can be determined independent of wind, temperature, and turbulence in 0.9 seconds per passing car. It is effective at measuring vehicles traveling between 2.5 and 150 mph. They have been shown to give correct readings for CO and HC by means of double-blind studies of vehicles both on the road and on dynamometers (Lawson et al. 1990; Stedman and Bishop, 1991; Ashbaugh et al, 1992).

Variable Message Sign

The operational test combines a remote sensor to determine vehicle exhaust emissions with a custom variable message sign to display emission levels to the driver.

The variable message sign was designed and constructed in cooperation with Skyline Products Inc of Colorado Springs, CO. It incorporated many of the advanced highway sign technologies which are currently being used around the country and took advantage one new product. Research suggested that three emission categories were needed to fully cover the

Is it getting good readings now?

Well, I took it through right after that and I got a good and then it started going back down again - I got to where I wouldn't even go up the ramp - it was too disheartening because that was a lot of money - so I took it through about two weeks ago and got a fair - I've driven through about three or four more times and I got good, so

You think the sign is good, helpful?

.Yes, I do, I really, really, do - I just hope it's accurate - after what I've been through - I put a lot of money into the car and to go through and get a poor and a fair and start getting goods all of a sudden - nothing else is changed on the car - I kind of question - what else is it picking up - is it cleaned all the time - I don't know if all the filters that they have are cleaned

After you got the repair to the car did you get a poor after that?

Yes, mostly fairs and then it went to poor and then back to fair, fair, and then it finally started going up to good

What do you think about the brochure?

I haven't seen one before - yea, I had a tune-up first because I thought that was the problem -just a plain tune-up and I thought that will solve it and it didn't, I was still getting poor, so I went back and they did a diagnostic - I tried everything - but it's real important to me that I don't get poors because I don't want to hurt my grandkids here

Would you have liked to have seen this before you went by the sign?

I already had some idea of what was going on

Do you agree or disagree that keeping your car well-maintained actually saves money?

Absolutely - I think if you keep your car tuned you're going to save certainly on gas - and this air flow thing I had replaced, I wouldn't have thought of it in a thousand years, but it needed to be done w/it had really shut down

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Yes, I think it can - I was always under the impression, if a car is polluting, it's belching stuff, and it's not true - that's what that taught me - when I was first getting goods and started getting poor, it wasn't belching

How much would you be willing to pay to fix your car so that it falls into the good category?

\$400, plus the tune-up before that was another - this was a total of \$500 dollars with the diagnostic and the air flow thing - and I had a tune-up about three weeks before that was another \$75 dollars - it's very costly, but I need the car and when I have problems I need to get it fixed

In your opinion, what is the air pollution problem?

I think it's mostly vehicles, but there's a lot of things - there's construction, but mostly cars I guess

External factors that the group felt were important included the potential for a driver being shown the wrong emissions reading due to variance in the ramp speed of the vehicles. Drivers not having enough time to read and process the information from the sign. The natural emissions variability and thus inconsistent readings of some vehicles. The language problems of some population segments and the potential for inconsistent messages between the sign and other vehicle inspection programs. Many of these concerns were viewed as largely uncontrollable from the standpoint of the operational test but important to consider in advance to assure the credibility of the information.

Concerns about the methods and design of the study involved the question of generalizability of the data. Would the public perceive the license plate reader as an invasion of privacy? How would we involve the media? A concern was expressed that we needed to downplay the government role.

All of these participants felt that the communications aspects of the program and the design of the sign to be the most important. They felt the sign should use color for attention getting purposes and to assist in conveying information. That some type of scale with pictures were preferred over words and numbers. The scale used needed to have an understandable rating system and we needed to keep the sign simple and humorous.

This information was collected and used to refine the questions and issues which were next submitted to two focus groups from the general public. In February of 1995 two groups (one men and one women) of randomly selected drivers were assembled for a two hour discussion of general air quality concerns and their perceptions about the Smart Sign. Graphic designs of potential sign concepts prepared by Conoco, were viewed by each group and comments were taken. Figure 2 shows a graphic which included all of the various test elements that we examined in the groups.

Conclusions of the groups were that the idea of a variable message sign offered as a public service was viewed very favorably. This favorable view grew out of the groups interest in improving Denver air quality and the idea that current access to vehicle emissions information was too infrequent. They encouraged us to make the sign fun emphasizing a lighter side encouragement as opposed to a “big brother” type of big stick approach. The groups also wanted the sign to stay away from numbers in favor of Good/Fair/Poor and to use monetary incentives as opposed to environmental concerns. The women were especially emphatic about money being a stronger motivational message.

Key Features

The Smart Sign design that emerged from the focus groups was one which involved a multi-colored variable message sign which would could provide emissions information to drivers on several different levels. It was widely acknowledged that all of the information on the sign would be difficult to comprehend in a single exposure and our exposure experiments show that different people were drawn to different elements in the sign. The sign design team took

Would you have liked to have seen it before you went by there?

Yes - At least I would have known what the hell it was

Do you agree or disagree that keeping your car well-maintained actually saves money?

I agree - 'You get better gas mileage - more efficient

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Yes

How much would you be willing to pay to fix your car so that it falls into the good category?

\$250

In your opinion, what is the air pollution problem?

vehicles mainly - you go down I-25 in a day and there's too many people - too many single people in one car

What do you think is the cause of the brown cloud?

Vehicles are the biggest daily contributor - I work at a place where the emissions are pretty well-regulated - industry is not as bad as it used to be - it's just the amount of people on the roads - it's always going to increase, I think

What do you think causes the brown cloud, specifically?

Sand is part of the problem too

What do you suggest we do about the problem?

I heard out in California that they've got a one time exemption on their vehicles - if you fail the test one time, you're exempt, but after that, if it fails again, it's not real worthy anymore and they suggest you get rid of the vehicle - I know a lot of people can't afford that, but if you want clean air, that's the price you got to pay - and maybe start using some chemical de-icer

Would you be willing to participate in an emission based registration fee program?

It depends on who made the numbers - I think the government has a tendency to overregulate everything so, I'd have to see something like that on paper

In general do you have confidence in the work that the government does?

Certain parts of it I do and other parts of it I don't

In general, do you have confidence that the government can improve the air quality?

I know they can - except what price everyone wants to pay

The sign was constructed with an all aluminum cabinet and sign face. For service the front face of the sign could be raised and lowered via a screw drive located on the bottom edge of the cabinet. To improve the nighttime viewing the declarative statement and the cartoon car would be back lit using standard fluorescent bulbs. This was accomplished by machining the outline of the characters and the car into the aluminum face plate. To improve the nighttime viewing of the remaining sign features, diamond grade Scotchbrite reflective sheeting was used for the white plume outline and the blue background. All of the LED segments were masked against a black background except for the radiator area of the cartoon car. This area was masked in a grayish white to give it a more car-like appearance. Finally the entire face was covered with a single sheet of polycarbonate sheeting to prevent damage to the sign facing from vandalism. The final product is shown in Figure 3.

SITE CONSTRUCTION

The site selected is located in the southwest quadrant of the interchange between southbound Interstate 25 and eastbound Speer Blvd. (see Figure 4). The site had previously installed electrical hook-ups on both sides of the off-ramp. Site surveys were conducted by Merrick Engineers & Architects and utility permits were obtained from the Colorado Department of Transportation.

Additional site preparation was needed to route the electricity to the five equipment locations on the outer edge of the ramp and to a single installation on the inside edge of the ramp. A phone line needed to be installed. Underground bunkers for the detector and the source needed to be constructed and concrete footings were needed for the VMS sign mounts.

Site preparation began in October 1995 and continued through February 1996. The two companies utilized for site preparation included Utilix and W. L. Contractors, both of Denver. Conduit was installed from the nearest telephone pedestal located about 300 ft. west of the site. Installation of this conduit was accomplished via a directional bore. Additional trenching and conduit was laid from the location for the control cabinet to the signs location, to the remote sensor bunker, to the utility pole which would hold the license plate reader and the location of the optical sign triggering device. All conduit was installed to meet the installation requirements of the Colorado Department of Transportation. Electrical wiring and signal cables were installed in separate conduit.

Approximately 250 ft. up the off-ramp two concrete bunkers were prepared below ground level to house the detector and source units. The detector bunker was constructed using two pre-cast concrete pipes (2.5 ft long 3 ft ID) fitted with a 3 1.5 inch diameter aluminum manhole ring and lid. The manhole ring was cemented to the top of the two precast pipes. The source bunker, located on the inside portion of the off-ramp, was fabricated at the site from concrete. This bunker is a 24 inch diameter cylinder approximately 5 feet deep with a square aluminum hatch and mounting ring. The bottom of each bunker was lined with approximately 3 inches of coarse gravel for drainage purposes.

In your opinion, what is the air pollution problem?

What I see is, places like the oil plant in Commerce City, you just look down there and you can just see the smoke rising from the smoke stacks causing all the smog around the city, but it's probably a lot from cars also - just on I-25 going into Denver because from our house you can see most of the smog is concentrated over Denver - it's starting to be a problem - I'd like to see it change - I really don't want Denver to end up like some other place like L.A. - It's probably not in the near future happening - it still is a problem - you can see the smog every morning when you look out there and Denver, just where it's situated is not a good area - there's not a lot of air flow sometimes - it just sits there a lot of the times - if we do something about it right now we wouldn't have that problem - there's not any lasting problems right now, I don't think, but the problems could develop after a while with more people coming into the Denver area - just with more cars

What do you believe the brown cloud is caused by?

I think it's both cars and smoke stacks from different plants down in Commerce City and Denver

In your opinion, what do you suggest we do about the problem?

I think, things like this - letting people know about their car's problems - you can't go out and force people to go get their car checked because it's damaging the environment - most people are like, oh well - if you let them know that it's actually costing them money to have their car run like that - they'll really go get it fixed - in the process of doing that they'll make their cars cleaner for the environment also - I don't really know anything we can do for the refineries - I know there's a process they can do to eliminate a lot of the waste they send into the air, but I know we could eliminate probably half of the pollution we have now by getting people to have better emissions from their cars

Other solutions?

Electric cars - they would eliminate the smog in Denver - have no emissions

Would you be willing to participate in an emission based registration fee program?

I think that would be a good idea - programs like that would really help because I don't know if it would cause people to try to understand the problems their cars are causing for the environment, but they understand it when it's cutting into their money and cutting into their paychecks - they don't want to pay for things they don't have to pay for

In general, do you have confidence in the work that the government does?

There are some things that I see that are so inefficient, just ways of doing things and it just seems that everything is based on money still

In general, do you have confidence that the government can improve the air quality?

I think there are agencies in the government that would try to make the environment better through Congress - through passing stuff - it just depends on who's lobbying them the most - I think if those agencies got more funding and more resources then I think they could really do a lot - like programs like this and more things like that

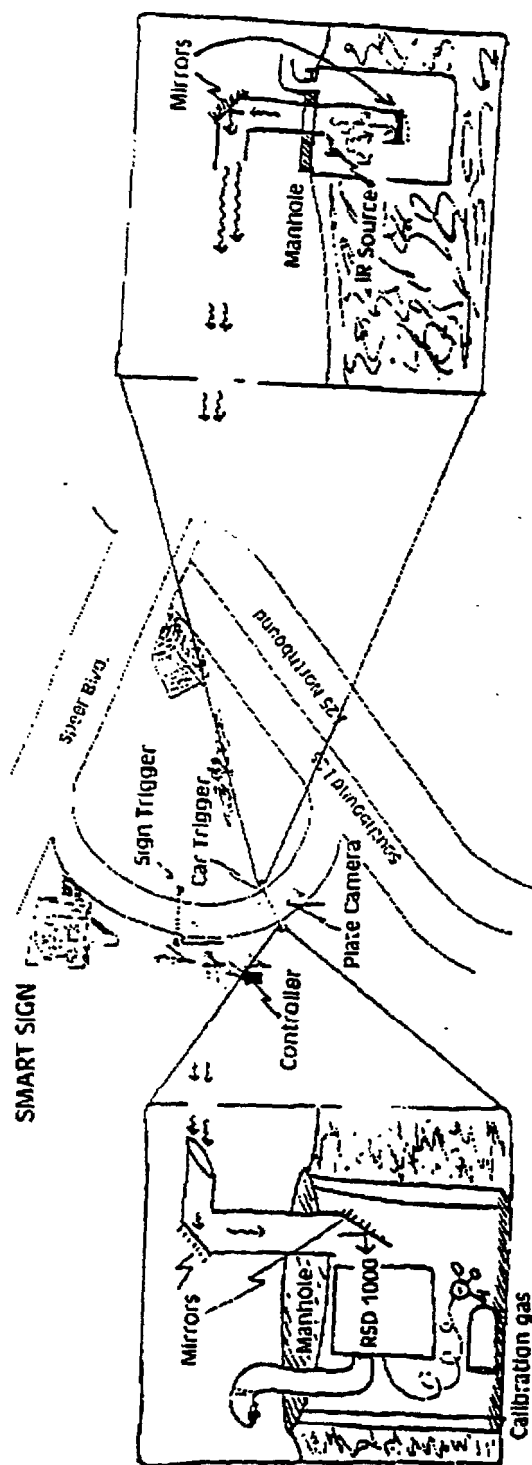


Figure 4. Artist rendering of the site layout at Speer Blvd. and Interstate 25. The enlarged views give a schematic representation of the detector and source bunkers with the optical periscopes.

Case #11

Good

What was your first impression of the sign?

I had no idea what it was about - I know it was telling me if my emissions were good, but I didn't know who was sponsoring it - I thought it was a neat idea - It did catch my eye right away

What do you remember about the sign?

The reading said your car's health and there was this bubble and this car *next to* it with a smile on his face that says, your health's good, saving you money - then there's a number at the bottom you can call if you have any questions

How many times have you been by the sign?

Now, probably about 5 times

Did you call the phone number?

No - I thought it was interesting, but I didn't think too much about it until I got the call

So it was pretty easy to see?

Yes, it was right there

Would you have liked an earlier sign saying what was coming up?

That might be helpful- wasn't there a blue sign right before that or maybe it was right after that with the number on it again

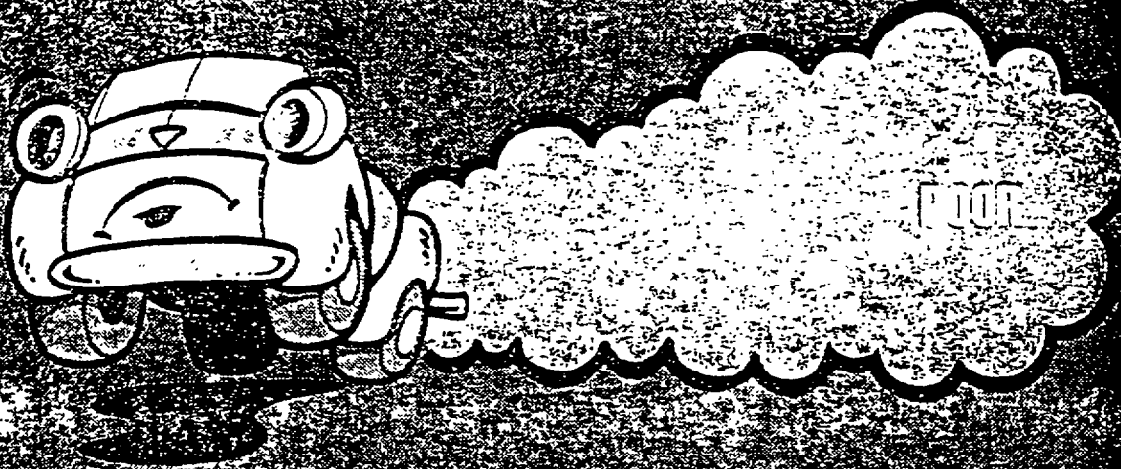
Describe your experience on the ramp?

The first time I was coming around I didn't see what was on the sign, I just saw flashing stuff, the angle I was at I couldn't read it, then I saw this thing over by the road, that was pointed at the cars and my first impression was, maybe it's taking your speed of your car just because I know that they have a lot of those things now and it automatically takes your speed and it'll take your picture, take a picture of your car and then send you a ticket in the mail, but I slowed down to make sure I was going the right speed

Why do you think it's there?

Well, I think it makes people aware if their cars do have bad emissions then they need to go get them checked - a lot of times it's not just hurting them and their checkbook in causing them *to* pay more money for their cars, but it's also causing more emissions into the air than we need

YOUR EMISSION IS:



**An efficient vehicle
saves you money.**

FOR MORE INFORMATION, CALL:

555-2345

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Do you think anyone is going to do anything as a result of the sign?

I would think so - I think the average person would probably - I see a significant number of people who would be curious as to why they got a bad reading and still passed emissions

What do you think about the brochure?

Yes, this is neat

Would you have liked to have seen that before you went by the sign?

No, not really - I kind of guessed what was going on - I have a science background so stuff like this kind of interests me - I took a class with Larry Anderson at UCD

Do you agree or disagree that keeping your car well-maintained actually saves money?

Agree - if you don't have your car tuned right then it's not going to completely burn all the gas, so when gas isn't burned it's going to go out the tailpipe

Do you agree or disagree that keeping your car well-maintained can reduce air pollution?

Yes, for the same reasons (as mentioned in the last response)

How much would you be willing to pay to fix your car so that it falls into the good category?

For me, I guess I look at that as in the performance and efficiency - it's not so much that I want to pass that sign as good, but I know my engine is not running good when I want it to - and I like to be as fuel efficient as possible - more so not that I want to save money on gas, but if my engine is running as efficiently as possible then it's less wear on it and it's going to last longer - so with that in mind - I would probably pay whatever it takes

In your opinion, what is the air pollution problem?

The majority is automobile exhaust pollution - some of it might be just dust stirred up by cars too - the next thing would be factories - in winter the fireplace

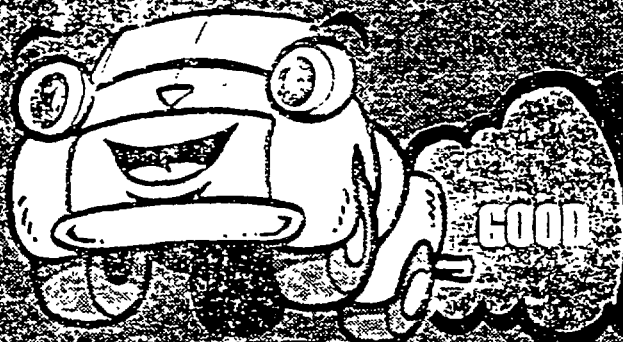
In your opinion, do you think we have an air pollution problem?

Yes - one of the things I think about is all these people jogging along the paths and stuff - it bothers me to wonder how deeply their sucking in all that bad air into their lungs - especially along the busy streets and stuff like that - it bothers me enough to get a place up in the mountains to get away from the air pollution thing

What do you believe the brown cloud is caused by?

Mostly the Nox's hydrogen, oxygen compounds and dust - I think that's what's making it brown, but I think there's a lot more junk in there that's clear that people can't see

YOUR EMISSION IS:



**An efficient vehicle
saves you money.**

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In your opinion, what do you think we should do about the problem?

Well, idealistically - if it were a perfect world - people would not have to drive so far to work - a lot of people do a lot of inefficient running around - they'll go somewhere - then they'll come back home - then they'll go somewhere else when you can make a trip and do a lot of errands at one time - then if people would carpool, but it's very difficult to Carpool to any kind of a job because there are a lot of times when one person might have to work longer than the other or times might differ or if somebody accidentally had to go home in the middle of the day for some reason, emergency or whatever, then there you are, you're stuck without a car or the other person is stuck without a ride - if people were encouraged to work a little closer to home and operate in a smaller area, it might help a little

Would you be willing to participate in an emission based registration fee program?

That might be a good thing and it might encourage people to maintain better, however, if this was the way counties, cities, whatever, get the money, this might not be a good- thing because they would come up with another way because if you make people pay then people are going to say, "ok, I'm going to keep my car in better condition so I don't have to pay or I get a refund," - well then the county is going to say, "where are we going to get our money," then they're going to hit us with something else

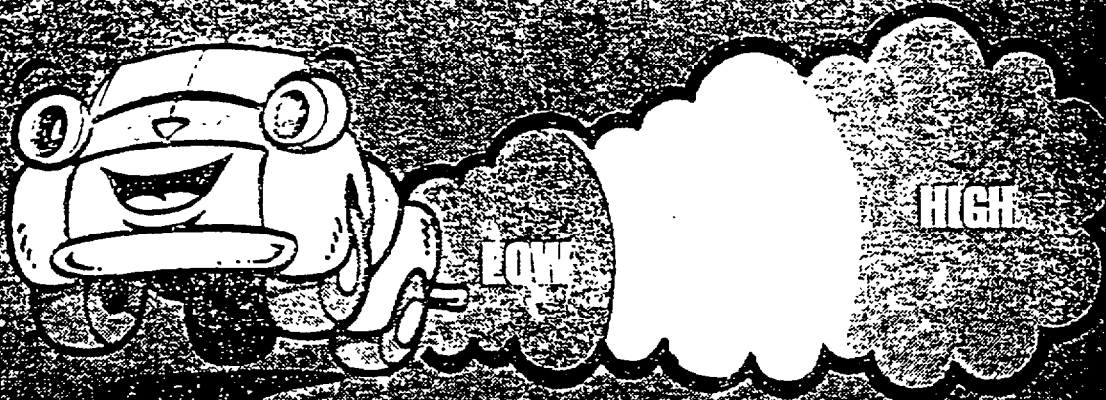
. In general, do you have confidence in the work that the government does?

In general, yes

In general, do you have confidence that the government can improve the air quality?

I think the government can improve the air quality only with the cooperation of the people - the government can't force you to do anything, and they're not going to - and I think everybody **has** to work together and something has to wake people up to this and I - you live in your little area and I have done that for quite some time now and then I went to work where I am and I can look out my window and I can see what's all around us and it is very brown - I mean it's not good - and so we need to figure out something before we harm our own health and mutate into something that we don't like

YOUR EMISSION IS:



**An efficient vehicle
saves you money.**

FOR MORE INFORMATION, CALL:

555-2345

Always wear your seat belt. Please don't drink and drive. © 1995 U.S. DOT.

Case #9

Good

What was your first impression of the sign?

I just noticed it, you know, I was driving up and noticed it was flashing a message and I read the message

What do you remember about it?

I just remember seeing it - because I wasn't really sure if this was a real thing and I thought ok this must have read my emissions and it gave this message - your car is saving you money or something like that - I can't remember exactly what it said, but I was happy, that's good

How many times have you been by the sign?

Just a couple

Probe -

I didn't really know if this was something for real or not, but then I realized, I bet it is

Did you notice a second sign?

No (Probed)

Did you think it was pretty easy to see - it was pretty clear?

Oh sure - it was

Would you have liked an earlier sign saying what was coming up?

I don't think that's necessary

Can you describe your experience on the ramp?

The first time I wasn't sure what was going on - I got the reading and so - the second time I went through there I looked for the little thing that \at along the side of the road - the sensor thing

Why do you think the sign is there?

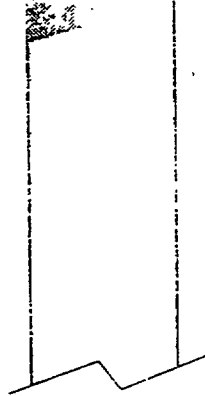
I didn't know who did it - I had no idea - I just thought it was kind of a little information thing that would help people sort of figure out whether or not their car was doing - what their car was doing on just a periodic basis - in between your emissions inspection - you know it was kind of nice to know that when my car hadn't been inspected for over a year - it was kind of nice to know that the emissions thing was still ok

In general, do you like the sign?

I think it's good - I think it's helpful - I think if people actually pay attention to it - I'm sure if you drove by there everyday it would become part of a landscape - you know you wouldn't pay attention to it, but if you go on a periodic basis I think it's good because it would tell you and then if your car wasn't doing ok then I'd taken it home and said to my husband, you know I got a bad reading today on this thing, maybe we ought to do something

**TAILPIPE
EMISSIONS
READING
AHEAD**

A Free Public Service



guys do that there's even a pollution problem - where the other one you're physically ill you're near the bay - nobody's gonna convince me and nobody's gonna convince the public even though scientifically it may not be true I can't say that that isn't worse, but the biggest one is that they don't have the infrastructure to handle the vehicle traffic and even when they have streets that could maybe handle the traffic they don't coordinate the lights so we sit there and pollute like crazy stopping at every single light so meanwhile they zap me for some stupid fee to go down to be tested when all they got to do is spend a little money coordinating a traffic flow and they would cut their pollution way down - I think the emphasis like everything else the government does is their grabbing the back end of the wrong thing - they won't let me bum the fireplace at certain times of the year, but they'll turn around and pollute like crazy with something else - it's stupid, the EPA was talking about putting pollution devices on lawnmowers - I mean, come on, a lawnmower gets run a half hour, an hour once a week and puts out almost no pollution at all compared to all this other stuff that's dumping out this other stuff - somebody make sense out of this one - I got off

In your opinion, what is the air pollution problem?

I think the infrastructure part of it - that they don't handle the traffic well - that's a horrible waste of fuel, increase in pollution - it's also counterproductive in a lot of other ways - it would be cheaper to put money in infrastructure than the wasteful way we do it now, but it's just like the pollution - it costs you money to fix the vehicle, but you don't see the little loss of money because it's not running well - nobody notices the incredible cost of all the incremental amounts of stuff by putting the money in infrastructure - the diesel vehicles, the state vehicles because they're not used to this altitude - you see a lot of that junk

What do you suggest we do about the problem?

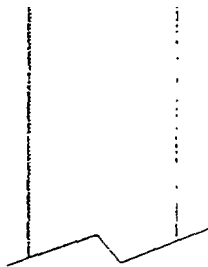
They ought to be building the proper amount of roads and the infrastructure of the traffic - for instance we have Wyndam Park which is going to mean a huge increase in people, but Ward road is going to stay just as small as it is - well right now, people are jammed up getting in off that road, but now they just dumped a whole bunch of more people onto that same infrastructure - well, that's going to cause pollution - the fact that that intersection and that road is not designed to handle that kind of load is going to cause more pollution than just the fact that people are moving there - and then there's things that they can do that I don't understand why they don't do - I know people in Southern California got annoyed when they put the evaporative return systems on all the pumps at the gas stations and that did cost money, but there's a lot of raw gas that gets pumped out into the air - and I came here with the higher altitude and therefore gasoline evaporates even faster - then we put those oxidizers in and those evaporate very, very quickly - and yet we have no systems on any of these gas stations there are things that they could do that wouldn't cause a major inconvenience to people - the technology is a lot better than when they first put those things in

mass transit?

buses and all those things need regular schedules - a lot of groups including environmentalists - they need to wake up and smell the coffee - you're not going to force the American people to give up the car - so why don't you just get with the program and figure out ways of making them better and more efficient

TAILPIPE EMISSIONS SIGN AHEAD

A Free Public Service



Case #8

Poor

What was your first impression of the sign?

I don't remember that sign, that well - I saw it when I was in Pheonix - so I had already been familiar with the concept and familiar with what they were doing - I didn't have any negative impressions of the sign

How many times have you been by the sign?

I just went by once - was surprised to see it

What do you remember?

It was nicely worded and something about my car did poorly

Did you understand what they were doing?

Yes- overall my response was positive

You noticed the message?

I remember that even though it told me my truck wasn't doing well, it did it nicely - it wasn't offensive - it told you how your car was doing - I think it even said if you have any questions call - it was something if I drove by everyday I would know more about it or remembered the number, but I only went by once

Would you have liked an earlier sign saying what was coming up?

I would think that would defeat the purpose - that would be like having a sign saying a police officer is up ahead - people would avoid going that way

Easy to see?

Very clear, positively worded - I'll give you my bias up front - I hate the system we have now - I think it's counterproductive, it's expensive, it's a waste of time, and it doesn't produce the results it's supposed to produce - a passive system, I think, that was enforced, would make more sense - much like the speed traps we used to have when I lived in California - radar with cameras - people had to start paying attention to the speed limits - well this is kind of like the same thing - (now) you go in you get it passed and then you change it so it runs - well, what did that produce, not to mention I don't trust this particular system anyway

this makes sense - instead of making everybody go down and get a test every so often and charging them money for it and all the hassle that's involved in that and inconvenience and everything else - if they put those things around then you'd get the ones that are actually causing the problem - so as far as I'm concerned that gets you more bang for the buck - if the purpose is to clean up the air then I think that's more effective - (this - Envirotest) I think is only there to generate revenue

positively along with the linked messages of the car rating and personal pocketbook effect.

The primary discussion centered on the substitute for “Emission” in the heading. Between our two alternatives - “Performance” and “Your Performance ” - the clear preference was for “Your Performance” because it personalized the message to the driver. Performance, however, was viewed with some skepticism because of its variable meaning, either referring to the driver’s performance or the car’s.

This generated a discussion in which many other alternatives were proposed:

- Your car is
- Carbon monoxide
- Score
- Car
- Exhaust
- Fuel economy

When discussion was encouraged to get people to think outside the given parameters, several interesting suggestions emerged. One was to use symbols inside the plume to add communication (e.g., gasoline can).

But, the most promising was to tie the message to the health of the car. The advantages are that it is a double play on the health of the car and individual health (n.b., strong pollution and CO connection here) and it easily encompasses the three key dimensions of fuel economy, emissions, and driveability. Additionally, the pocketbook message as a tag line is still relevant. The strongest phrasing seems to be:

YOUR CAR’S HEALTH

The tag line alternatives discussed were:

You’re saving money
Saving you money
Saving money

You’re wasting money
Costing you money
Costing money

No consensus emerged in this area, particularly when paired with the “healthy” alternative lead-in. There was some discussion about changing “money” to “fuel”, but the final consensus was that money was a stronger motivator. Among the given alternatives, the slightly stronger candidate was:

SAVING YOU MONEY

COSTING YOU MONEY

Case #7

Poor

What was your first impression of the sign?

Thought it was pretty interesting - heard a lot about them doing the remote sensing

What do you remember about it?

I just remember the poor

Anything else?

No

How many times have you been by the sign?

twice

Understood what was going on?

Yes, because of the media

Remember anything else - bottom of sign?

No, pretty tight comer

Notice a second sign?

No

Pretty easy to see?

Poor was easy to see - registered poor, knew he'd been sensed

Would you have liked an earlier sign saying what was coming up?

No, knew what was going on already

Why do you think the sign is there?

I'd imagine it's a test for doing this on a larger scale - similar to the speed cameras

How did you feel about seeing the sign?

Found it interesting from a technical point of view - you're putting out a certain amount of emissions

You like it then, you think it's good, helpful?

I think it's really helpful because my car read poor

Do you think anyone is going to do anything as a result of the sign?

It'll probably be done through the emissions test - I certainly haven't done anything

- Clean up “emission” related wording
- Take out “free public service”.
- Wording that suggests action following multiple poor readings.
- Resequencing questions.
- Unclear how to relate to centralized emissions program.

cc: Don Steadman
Gary Bishop
John Bennett

How did you feel about seeing the sign?

If you got a good reading then you go oh, everything's good - on the other hand, if you got a poor reading, costing you money, then it subjects you to a conscience, awareness, that says no only is your gas dollars being fueled away, but you're not as efficient - let's see I have an emissions sticker coming up here pretty quick, I better get this fixed and not leave it to the last minute, so those kind of things - when it showed a good reading, it did give you a connotation like ah, there is something right in the world today, my car is running good

Do you like it?

I think it's kind of a fun tool - it's different so it makes it an interesting tool - wonder how are they reading that? - what kind of technology are they using?

Do you think anybody will do anything as a result of the sign?

I think it's going to be the same motivation as it is with most people - is it time for my emissions sticker - when do I have to do it - I've got a heads up now that something's not tight - at least I can go in and get the emissions sticker or have work on it before I get turned down and have to go back again - at least it's a heads up - when you get turned down for a sticker and you say I had no idea- that's not true

What do you think about the brochure?

At least it gives you a guideline - they talk about cars of '75 and '82 vintage and what you would expect to see - I would like to see more of how it works - curious

Do you agree or disagree that keeping your car well-maintained actually saves money?

Yes, the fuel issue and the spark plugs, there is point where you can either clean them or replace them - carbon in the engine - it just makes sense, it bums cleaner, it runs cleaner

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

In the Denver market I don't know if you can, because right now we're experiencing incredible growth - the only way you can do that would be to compare a ratio of population vs. a ratio of worsening of pollution - how you would register that with temperature inversions that the Denver arena has, I don't know - I don't know how you could clearly say it's getting worse - only it was this way in '82 and it was this way in '96 and because it's worse it is worse

How much would you be willing to pay to fix your car so that it falls into the good category?

Most people will spend \$100 dollars to keep it up - but, it's only because if they don't they're not going to be able to drive that car, because of the emissions thing - people aren't going to do things unless they're forced to

What is the air pollution problem?

A lot of it's particulates

.....

What Is The Smart Sign?

Although there have been significant improvements in recent years, Denver still suffers from dirty air and an air pollution problem that is destined to get worse as the city grows.

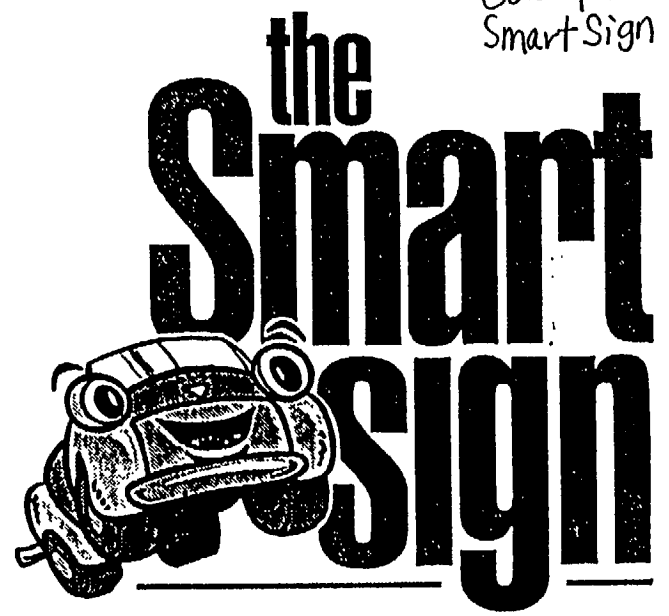
To raise the public's awareness of this ongoing problem, an innovative emissions measuring device has been installed at the Speer Boulevard exit ramp from Interstate 25 (North, South?). At that location, exiting vehicles will pass through an invisible infrared beam which measures carbon monoxide emissions. In less than a second, the Smart Sign will flash a reading of GOOD, FAIR or POOR to help motorists assess their vehicles' fuel efficiency and overall condition.



Sponsored by
 Conoco and the University of Denver
 with assistance from
 Colorado State University,
 RSD Tucson,
 Skyline Products,
 U.S. Department of Transportation
 and
 Colorado Department of Transportation



Swatch
 of actual
 color for
 Smart Sign



A Quick Way
 To Measure
 Your Car's
 Efficiency And
 Emission
 Levels.

What do you suggest we do about the problem?

Install light rail

If the light rail was accessible (for example, if it stopped within 2 blocks of your home and work), would you pay \$10 dollars for a monthly light rail pass?

Yes - probably \$50 dollars a month

Would you be willing to participate in an emission based registration fee program?

Pd be glad to, if everybody else had to do it - but what happens now is that we all have to maintain our cars and get our air pollution and there are those who don't so we end up paying for it - it's an obligation on everyone's part

How much would you be willing to pay for an emission's test?

Not gonna pay any more than I have to

Do you have confidence in the work that the government does?

Absolutely

Do you have confidence that the government can improve the air quality?

Yes, with work, it's going to take a while - surveys such as yours and more testing I'm sure will help clean it up and more environmental conscious age so I think that has a lot to do with it and future citizens are more environmentally aware - I have no doubt that it's going to come down on us

PERFORMANCE

includes

FUEL ECONOMY

EMISSIONS

and

DRIVEABILITY

They are all related as you will see when you read the rest of this brochure.

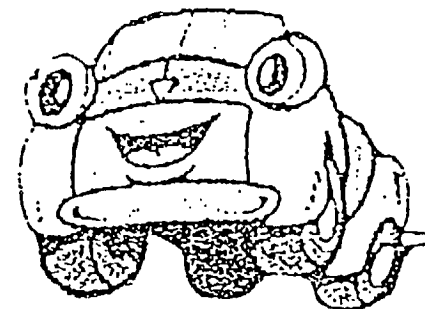
The Smiley Car sign operates by measuring your instantaneous Carbon Monoxide (CO) emissions.

Most vehicles get "GOOD"
some will get "FAIR"
a few will get "POOR"

Read on to find out what to do about these readings.



each agency logo here



Smiley
Car
Indicates
Performance

Program operated by

University of Denver
Colorado State University

With Assistance from

Colo. Dept. Of Transport, Colo.
Dept. of Public Health & Env't.,
Conoco, Skyline Products,
Remote Sensing Technologies,
US Dept. of Transport.

FOR MORE INFORMATION CALL
871-2585

Brochure by CONOCO

Case #5
Good/Poor

First impression?
Is this measuring my speed or exactly what is it doing?

What do you remember?
The car, the happy little face - after I read something about it in the paper, I knew it was for the pollution - as I drove by, it said good - always good to confirm that you're doing ok

How many times have you been by the sign?
numerous

Did you notice the message at the bottom of the sign?
No

Did you notice a second sign?
No

What was it like seeing the sign?
Very easy to see

Would you have liked an earlier sign saying what was coming up?
Yes, a sign saying emissions testing ahead and then I would've had a better idea of what was going on - might have paid more attention to it as opposed to, you're here - and then you pass it and you say, geeze, I wonder

Describe your experience on the ramp?
I really didn't pay much attention to it other than it works - cause I had watched them put it together for a few weeks and wondering what they were doing - thought it would be a speed trap - I thought, another testing tool

Why do you think the sign is there?
I think we have some problems with the federal EPA in not meeting federal standards and I know that it's attached to some federal funding - so I had a pretty good idea that in measuring to see if we are meeting or trying to meet standards to see that we continue to get federal funding - I'm sure it's attached to federal funding somewhere

due to the additional computer time needed to process the plates. So a typical weekday will see approximately 12,000 vehicles use the exit ramp, however if the LPR system is operating the system will only be able to serve approximately 10,000 vehicles.

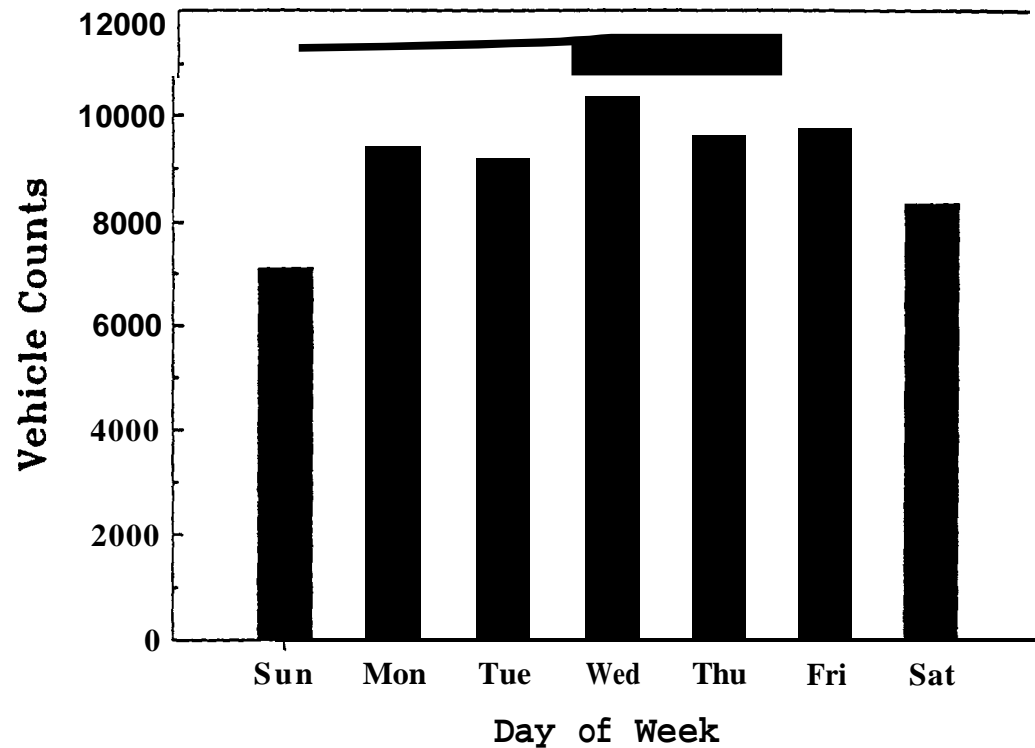


Figure 5. Average vehicle volume by day of week for days the Smart Sign system was operational even for only a portion of the day. Data collected from May 1996 to December 1996.

Table III lists the operational hours on a month by month basis. The percent of up time improved each month that the Smart Sign has been operated since May 1996. The one exception to this is for the month of December. A contractor installing a sidewalk at the Speer Blvd./I-X interchange cut the main power cable to the site on the 23rd. This power outage was not repaired until December 31. This long loss of power accounts for 95% of the downtime in December.

Overall the sign has been operational for more than 87% of the possible hours through December 1996. Several additional modifications are planned in 1997 which should further improve the operational characteristics of the sign.

In general, do you like the sign, do you think it's helpful?

Helpful to who? - Whoever is running the study hopefully - to the general person I doubt it - to me in particular it wasn't because my car is so old there's no way it's going to meet a quote average, quote pollution standards - I don't think that the requirement to pass emissions has accomplished anything - other than take a lot of money out of drivers pockets and put it in the hands of other people - I think the improvement in pollution has strictly got to be with dynamics - the cars that the EPA forced to become such high polluters back in the 70's now are running 300,000 miles and they'll soon be dead and the new cars do much, much better

Do you think anybody is going to do anything as a result of the sign, in general?

Well, if I was driving a new car and it came up poor, I would check it out immediately because it shouldn't - I don't even know what the machine is set at, does it measure carbon monoxide, carbon dioxide, nitrous oxides? - the CO problem will go away as the 1990-1993 cars get older

How did you hear about this before?

Probably in the newspaper - I don't remember

What do you think about the brochure?

...Maybe if I go downtown again - I'll go by there and check it out again, just for grins

I think it's informative

Would you have liked to have seen this before you went by?

Since there's no specific information in it, it wouldn't have increased - the only thing I caught out of there was that it was set so that '82 cars could pass - I would've liked to have seen the level at which it was set - for the average person who doesn't know or pay attention to those things it would be misleading - they would assume that the ratio between the different years is a linear function - it's not - we've got cleaner air in spite of the EPA, not because of it

Do you agree or disagree that keeping your car well-maintained actually saves money?

absolutely, if you do it yourself - because the cost of having it fixed may exceed the savings

Do you agree or disagree that keeping a car well-maintained can reduce air pollution?

Sure, well, yes - even when after you take it through the test and they take it home and tune it, for which case it would flunk the test, but it's better for air pollution because you'll use less fuel - the less fuel you use, the less air pollution there is - the tests are often misleading - if you're interested in performance and economy you'll definitely tune it afterwards - you'll detune it to pass the tests and after that you'll tune it up - the tests aren't a true measure of the car running, even when they put it on the dynamometer - because they don't run full throttle or even three quarters throttle - they put it under a load, but it's a pretty light load - you don't do much pollution under light load - you do your heavy pollution under heavy load you can pass a pollution test with a dirty air filter

How much would you be willing to pay to fix your car so that it falls into the good category?

In my particular case I didn't spend a dime because it was already running good- for the older cars it is not practical to go down and get an overhaul because the sign said so - if you have a '96 and it fails you better take it in and get it fixed because there is something seriously wrong with it -

Envirotest, if it failed? - usually, what you do is unplug a vacuum line hose and that will put you into compliance or you can go to a different Envirotest - they report to be very accurate, but the repeatability is very poor

What do you think is the main air pollution problem?

Dust - the brown cloud is dust - not as bad now as it was in the 70's- because of public service using natural gas now instead of coal and they don't use as much sand now as they used to - particulates are the definitely the biggest problem - the carbon monoxide, I think, is irrelatively innocuous - for years, remote sensing in Denver, they'll used a dome to measure the flowthrough and a lot had to do with which way the wind was blowing - to measure the city as a whole you have to pull your sensors off the road quite a ways to read. the mixture up there - of course as soon as you do that the city would be in compliance all the time - you have the maximize the problem so you have a reason for being in existence

What do you suggest we do about the air pollution problem?

I don't think there's a need to do anything - the problem is going away by itself
- the pollution tests have had no effect, it's just a way to milk the customer

Would you be willing to participate in an emission based registration fee program?

Absolutely, I can pull off lots of hoses - interesting concept, but I would be against it because I can't afford a new car

It's a problem that's going to go away (Air pollution)

Do you have confidence in the work that the government does?

No

Do you have confidence that the government can improve the air quality?

Absolutely not, the government never improves anything - whatever it gets into, it screws it up

Table I. Smart Sign Operational Situations and Corrective Actions

Weather Conditions Problems	How Detected	System Response
Rain/Snow/Sand	When the valid measurement rate for the last 100 vehicles drops below 80%.	Smart Sign turned off until measurement rate recovers. System issues an error message.
Loss of IR Signal	Loss of IR signal should only occur when vehicles block the beam. A timer detects when a loss of signal is too prolonged.	A self-test is performed on the detector unit. If a problem found then a system reset is issued. If ok the system pauses then tries to monitor cars again. If this failure mode is repeated more than 10 times the system shuts itself down and issues an error message.
Data Transmission Errors from manhole to main computer	Data are serially transmitted in blocks with check sum error checking. Repeated check sum violations are used to detect this condition.	A self-test is performed on the detector unit. if a problem found then a system reset is issued. If ok the system pauses then tries to monitor cars again. If this failure mode is repeated more than 10 times the system shuts itself down and issues an error message.
Temperature Changes	Detector voltages violate preset upper or lower limits.	The system automatically resets the detector gain settings.
Sunrise/Sunset	Time of Day.	The LPR system was restricted to daylight hours only as a safety precautions due to its use of a strobe to illuminate the plates.
Hard Disk Full File System Failure	Detected by DOS system storage errors.	The system reports the error and disables automatic logging of data The Smart Sign continues to operate.
Power Failure	No phone response.	System is setup to automatically reboot and run the Smart Sign after a power outage. During the outage remote control of the system via the phone is impossible.
Position Sensor Failure	Detected by a persistence low voltage signal from the detector.	Smart Sign turned off. System issues an error message.

90's. During a rain or snowstorm this rate has been observed to range below 30% success rate. This means that there are periods of operation when the system is functional but the

The Safetran model 336 aluminum control cabinet was located on the outside shoulder of the off-ramp. Since the cabinet was located outside of the crash zone a concrete pad was poured for its installation. All of the electrical, signal and phone cabling located on the outside portion of the off-ramp terminated at this cabinet.

Merrick Engineers & Architects designed and certified the footings and steel mount for the sign. Two foot diameter reinforced footings were poured for the sign and a breakaway steel mounts were constructed by J & S Contractors to hold the Smart Sign.

SMART SIGN OPERATION

The Smart Sign began operations on the afternoon of Thursday May 16, 1996. Through December 31, 1996 more the 3 million measurements had been completed. The system has been operated in all types of weather conditions and extreme temperature ranges of -15⁰ F to 101⁰ F. High traffic volumes at the site have been experienced at the site despite a major construction project at the intersection during the Fall of 1996.

Probably the single most important component in the day-to-day operation of the Smart Sign was the use of a remote control software package. Early in the project it was decided that a dedicated phone line to the site would be used as the primary means for monitoring the Smart Sign system. Through the use of this software package we were able to communicate with the Smart Sign's command computer via standard phone lines from anywhere in the world at anytime. This allowed us the luxury of conducting the vast majority of system maintenance, testing and monitoring without having to visit the site.

Operational Parameters

This section will detail many of the operating criteria which have been developed over the course of this operational test. Many of these parameters have been chosen for operator convenience, while others were chosen to protect public safety. Many of these criteria have been used to evaluate the operating conditions and performance of the system and decide when service might be needed.

The original remote vehicle exhaust system was designed to have an operator present during operation, to be operated in a single lane environment and only during dry weather conditions. So one of the first tasks was to develop a list of weather conditions and instrument problems which would need to be detected and the actions which could be taken to best mitigate the situation. Table I provides a list of situations currently handled by the Smart Sign control program.

Operation of the sign was guided by the desire that the data reported to the public have a high confidence level. So that when rain or snow start to degrade the instrument's successful measurement rate we stop displaying the results on the Smart Sign. The choice of 80% as the determining point was a matter of convenience. The instrument normally operates in the mid

Smart Sign does not display any results because of external conditions or equipment problems.

It was decided to only operate the LPR during daylight hours out of safety concerns for the driving public. As previously described, the LPR system uses a xenon arc strobe system to illuminate the license plates of passing vehicles. This provides the opportunity for the system to function as well at night as it does during the day. Even though the strobe is pointed downward at the rear of the vehicles we were concerned that the flash might be a major distraction after sunset. Therefore, an operational decision was made to only operate the LPR system during daylight hours.

Day-to-Day Operations

The operation of the Smart Sign relied heavily upon the use of a modem to modem remote control program. The software system allowed nearly complete control of the system. Researchers usually checked on the system in the morning and evening of each day. More frequent checks would be conducted if changes in weather conditions occurred or if the system had been experiencing any operational problems. A log of conditions, vehicle activity, system operating parameters, system upgrades or changes, and any problems encountered were maintained.

Physical visits to the site were only conducted if a problem could not be resolved over the phone. Typical services items, their manpower needs and time required to complete are listed in Table II. Service visits average 2 to 3 visits per month with the activities changing with the seasons. For example, cleaning the source detector optics was required more in the warmer months, especially after rain storms. While in the winter, snow removal from in front of the vehicle position sensors was a more common activity. The decrease in cleaning the instrument optics was due to the colder temperature. At the higher summer temperatures clean optics were a necessity of optimum signal-to-noise considerations. Colder temperatures improved the RSD's detector signal-to-noise enough that dirtier optics could be tolerated for longer periods.

Most maintenance items were simple to conduct. Often during a site visit we would routinely clean the above ground optics on the source, detector and vehicle position sensors. This would require a small amount of water and several optical grade tissues. Each optical surface would be washed and dried. This normally required ten to fifteen minutes. For a more thorough cleaning or other maintenance action the source and/or detector would need to be removed from its manhole. The source could be extracted by one person and serviced while it rested on the ground. The detector unit, due to its larger size and weight required two people for safe extraction. After disconnecting the power to the detector unit, extracting the system required the manhole lid to be unlocked and a lifting pin installed into the top of the lid. Using a crowbar one would alternatively lift each side of the cover and install a large C-clamp on opposite sides of the lid. It was now possible to safely lift the lid and detector unit straight up. Once the detector unit clears the top of the bunker two 2x4's could be positioned

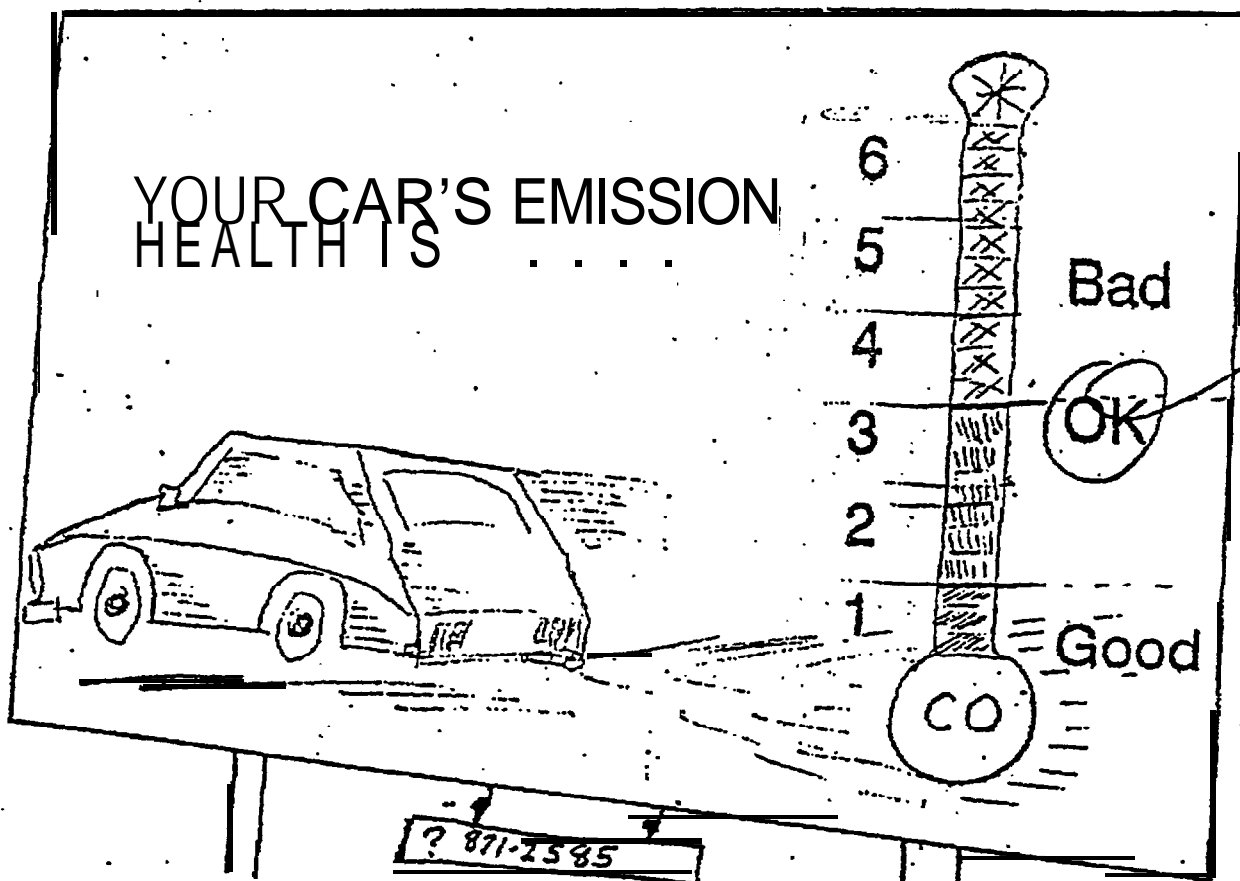
Table II. Smart Sign routine maintenance items

Routine Service Items	Manpower	Time to Complete	Service Frequency
Clean vehicle position sensors	1	15 minutes	Every 2 weeks or after rain/snow
Clean source optics	1	15 minutes	Summer: monthly Winter: Every 2 months
Clean detector optics	2	45 minutes to 1 hour	Summer: monthly Winter: Every 2 months
Backup data	1	1 hour	Monthly (does not require a site visit)
Clean/change air filters	1	15 minutes	Monthly

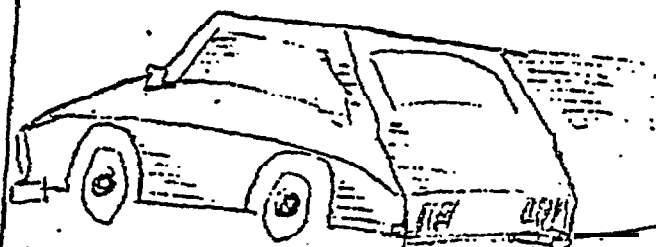
across the top to provide a shelf which the detector and lid combination could be safely rested on. Access is now possible to all parts of the detector unit without disconnecting any of the signal/power cables.

After reinstalling either the source or the detector unit realignment of the sensor beam would have to be undertaken. Of all the service items this is the most difficult and time consuming. Alignment tools include a visible laser beam which follows the path of the sensor detection optics, an audible beeper which changes frequency with changing signal levels and a graphical alignment computer display. All of these help the alignment process, but there is no substitute for practice. Alignment of the source is less critical and our experience has been that after the initial installation only minor adjustments are needed to return the source to its original position. Alignment of the detector unit requires more time and usually a more thought out approach. Extraction, cleaning and realignment of the source and detector requires 45 minutes to 1 hour to complete. Our experience has been that this is a once a month item in the summer and once every other month in the winter.

The Smart Sign's main computer system has enough disk capacity to store about a months worth of emissions data. At the end of each month these data were removed and archived either via a modem download or in conjunction with a site service visit. Data from this program have been archived to QIC-80 tapes on a month by month basis.



YOUR CAR'S EMISSION
HEALTH IS



6

5

4

3

2

1

Bad

OK

Good

CO

Red

delete

Orange

Green

? 871-2585

Vehicles need periodic
maintenance for better gas
mileage and lower emissions.

Your car's need is

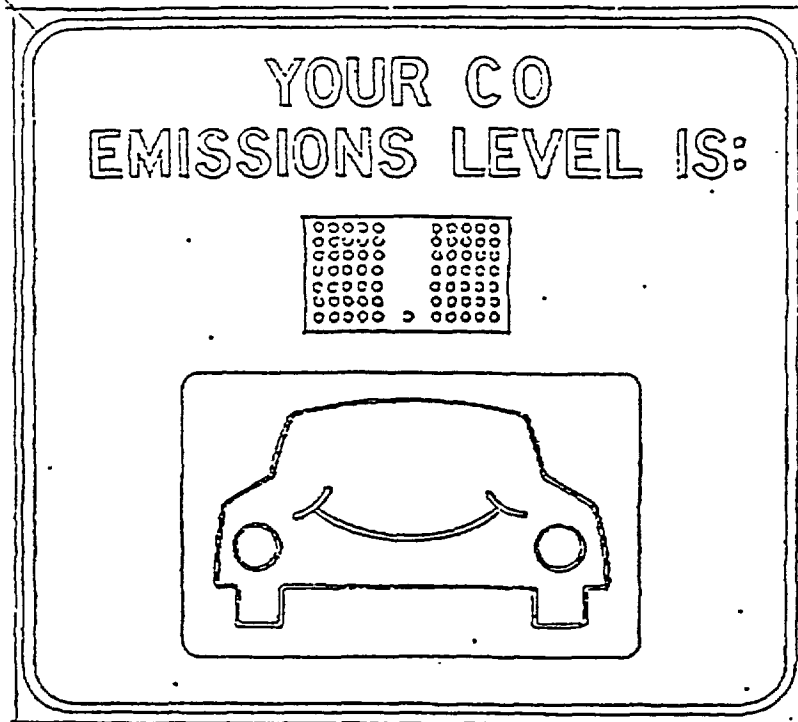
Not Measured

HIGH

MED.

LOW

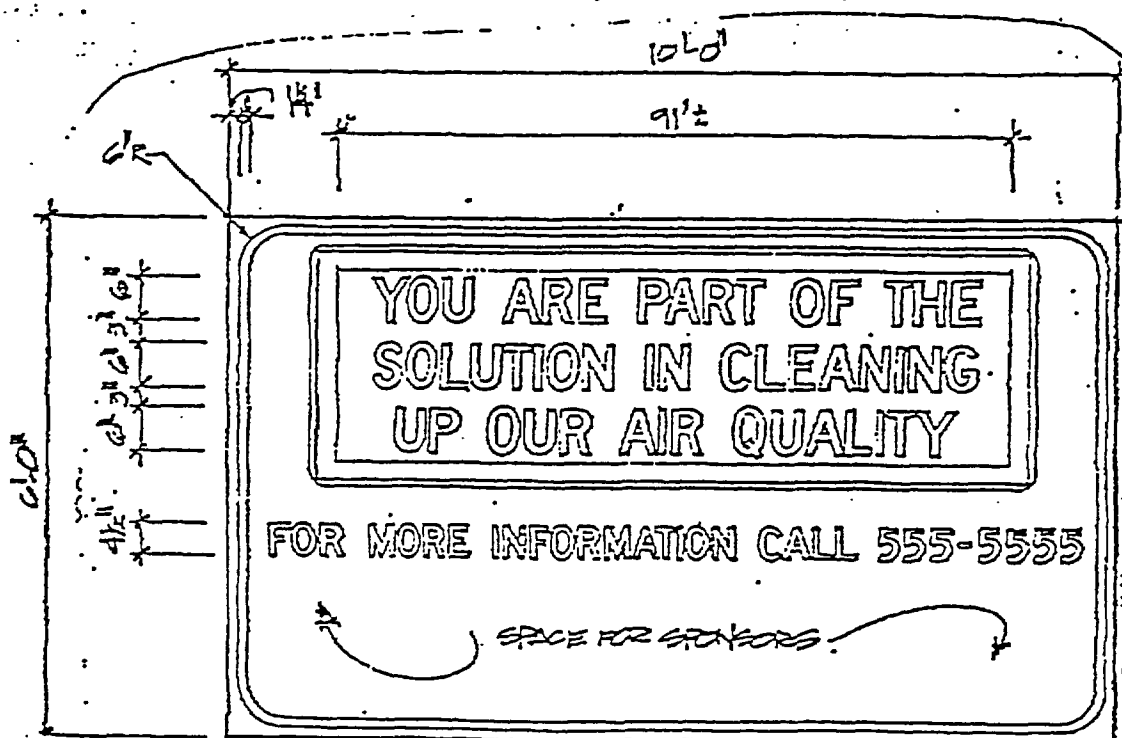
For Info dial 871-2585

[illegible]

7001 Deane Drive
Folsom, CA 95630
708-202-8040

1-800-726-0000

THE SICKYLAND PRODUCTS, INC.



RECEIVED FOR: CARPANO D.O.T. / INFO-PACKET.

DEINER CO.

107-116	10117-2000-0000	10117-2000-0000
107-116	10117-2000-0000	10117-2000-0000

	Chloride 0.1%	[Cl] = 1%
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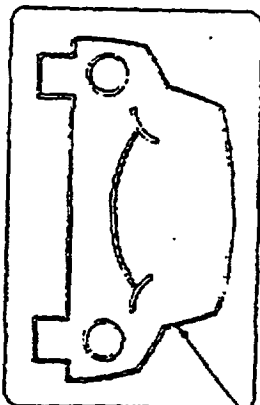
DATE	7/1/77	BY	W. J. H. H.
REMARKS	RECEIVED		
DATE	7/1/77	BY	W. J. H. H.
REMARKS	RECEIVED		

RECEIVED	BASE	WORTH	CO.	910-13	910-13
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FLUX MOLE CHANGES HERE = sign. (KX. DIFFERENT)

주머니.

114

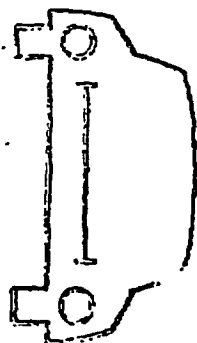
[illegible]

YOU ARE PART OF THE
SOLUTION IN CLEANING
UP OUR AIR QUALITY

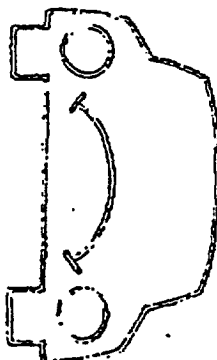
FOR MORE INFORMATION CALL 555-5555



Speedy Help



CHAS. C. CO. II NEON



CLEAR REFLECTION

FILM PACK
MESSAGE CHANGES

APPENDIX A

Variable Message Sign

Alternatives

- (5) The program and sign should convey that this is being provided as a service to the community and to each individual driver.
- (6) Everything must be done to take the burden of response off of the driver. How do we make taking action simple and easy?

These conclusions are demonstrated over and over in the group's design task (see Appendix B). What remains is to accumulate and integrate the best of these examples into several alternatives to take before the driving public to gain their input.

Content. The most critical area for decisions is in the area of content, that is what you want to say. A number of issues were raised, and consensus was gained on several courses of action.

(1) Off-line. When traffic is too congested or the system is off, there should be a message that the vehicle was not read.

(2) Numbers. Digital readings of emissions levels were viewed as too confusing. They are a difficult education message. They enhance the inevitable variability in the readings with multiple exposures, and they are hard to process.

(3) Message. Two types of messages were suggested. One was emissions levels in some form (e.g., thermometer, rating, color). The second was personal costs/benefits conveyed by dollar signs (\$). The former tracks the feature of the program but relates to air pollution, a community problem. Research shows that drivers are reluctant to change only for social good, especially when they conclude their contribution is very small. The latter relates to something everyone relates to - their pocketbook. It was felt that the combination could be a powerful motivator. A key question is how to convey the cost data (e.g., \$, \$\$, \$\$\$; \$50 ---\$100, etc.).

(4) Call-to-Action. Because of the complexity of the message and the subsequent decision process, the group concluded that in order for project goals to be met, there would have to be a strong call to action component. This call to action would be focused on the access of additional information.

SUMMARY

Several general conclusions can be drawn from the group discussion:

- (1) The final sign will be a creative blend of communication vehicles including symbols and color, with a minimum of words and few, if any, numbers.
- (2) The sign must be visually attractive. This may mean something besides a standard rectangle form.
- (3) Humor is essential to maintain interest.
- (4) The old KISS adage is applicable (i.e., Keep It Simple Stupid).

Method

Several issues were raised regarding the design of the study:

- (1) Generalizability. Because of the inability to read all licenses, there was a caution against “going beyond the data.”
- (2) Privacy. This issue concerned the appropriateness of reading the license plates.
- (3) Noise. Research efforts should measure the impact of extraneous “noise” during the test. The new emissions program is the prime example.
- (4) Variability. Changing the sign message introduces another variable into the project. This should be measured.
- (5) Communications. Involve the media from the beginning. Invite them for a preview before the program starts.
- (6) Credibility. Promote/communicate the program as being a DU/CSU effort. Downplay the government role.
- (7) inconsistency. Concern was raised regarding the potential for inconsistent message(s) between the test sign and other forms of emissions information (e.g., vehicle emission sticker).

Communications

The communications component of the test is the most critical, and can be divided into three broad categories.

Process. Because of the complexity of the issue, and the need for the drivers to access further information, process issues were perceived to be important to communications goals. In order to enhance the driver’s education, several suggestions were offered: (1) develop and implement an educational program prior to the start of the sign component, and (2) develop multiple outlets for the educational information (e.g., direct mail, supermarkets).

Another process issue involved how to maximize the value of drivers being exposed to sign information multiple times over the course of the demonstration. Multiple exposure will help learning and, therefore, to some degree mitigate the short exposure time for the individual drive-by. However, in order to promote continued interest, the message on the sign may need to vary.

The development of collateral materials is a critical path item. The brochure content and format, radio messages, and hotline content must be established. Much of the needed information areas can be defined in focus groups and with expert opinion. The hotline can either be manned in real time or taped answers developed. Or, some combination may be utilized.

A related topic is the development of additional communications support. Suggestions include the use of public service announcements (PSA's) getting coverage on local radio (e.g., NPR), or getting access to a free cellular phone number.

Design. Related to process is that of sign design, or how you say what you want to say. Design variables identified include the following:

- (1) Color. The sign should have multiple attractive colors to gain attention and assist in conveying the message.
- (2) Scales. Some type of scale is preferred to numbers. A thermometer type scale was positively received, positioned either horizontally or vertically depending upon sign format. The thermometer has added value in that it provides context for the amount. For example is a number like 3.7 good or bad and by how much? The worse the vehicle's emission, the more color on the thermometer and the more visibility.
- (3) Pictures. Pictures are preferred to words or numbers, for example smiling or sad faced cars. All three need to be visible in order to provide context for the driver.
- (4) Ratings. Ordinal ratings were felt to be essential. Several alternatives were offered (e.g., good-fair-poor, low-medium-high, pass-marginal-fail), Each has good and bad points. Pass/Fail could highlight differences between this test and the state test. Saying your emissions are "good" may be confusing since the issue is amount and not quality. Low to high may be the truest. All three, however, contain the potentially very confusing middle ground. This may be the biggest educational challenge of all.
- (5) Multiple Signs. Because the amount of information is greater than processing time, the issue of multiple signs arose. Because of the characteristics of the test site, two separate signs are not an option. Ancillary fixed position signs are an option, and their content and placement need to be decided.

Evaluation Report for ITS for Voluntary Emission Reduction: An ITS Operational Test for Real-Time Vehicle Emissions Detection

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Fort Collins, CO

May 1997

